IMPROVEMENT OF STONE FRUITS

F. P. CULLINAN, Senior Pomologist,
Division of Fruit and Vegetable Crops
and Diseases, Bureau of Plant Industry[1]

THE beautiful and delicious varieties of peaches, plums, cherries, and apricots that make up the group of stone fruits as we know them today are undoubtedly vastly different from their early progenitors. Down through the centuries many wild species and varieties have been selected by man in his search for new food supplies and a better diet. Just how long this slow process of improvement of the various kinds of wild fruit has been going on, history does not relate. As civilization progressed we know that many of these wild fruits were taken from their native homes and distributed to new locations where there were new soils and new climatic conditions. In these new environments certain modifications occurred in size of tree and in size, shape, color, and flavor of fruit. Many trees perished in the new environments. Perhaps only a few survived the vicissitudes of climate in some of the regions into which they were taken. Through these early chance selections, however, a beginning was made in the improvement of the stone fruits.

Stone fruits are now grown in all parts of the Temperate Zone in the Northern Hemisphere. In the United States the culture, production, and sale of these fruits constitute a great industry. In 1931, the peak year of peach production, the commercial crop was over 76½ million bushels. According to the census of 1935, the country produced in the previous year about 45 million bushels of peaches, over 23 million bushels of plums, and 5 million bushels of cherries. Peaches, plums, and apricots in the fresh, canned, and dried state are consumed in large quantities in this country and abroad. About 200,000 tons of peaches are dried in the United States annually. California alone produces about 75 percent of the world output of dried prunes. Cherries are commercially important as fresh, canned, and frozen products. There is little wonder that such a great industry should demonstrate weaknesses in many of our long-cherished varieties of home-grown fruits. We might imagine that after all these years of selection and discovery of new sorts, we would have reached perfection. Unfortunately, this is not the case; in fact, it may be said that

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the work of improvement has just begun. We must continue the search for superior fruits, locating and studying the best raw materials, and then using the methods available to the plant breeder to combine desirable characters in a superior progeny.

BOTANY OF THE STONE FRUITS

BEFORE attempting to consider the progress made in improving the varieties of stone fruits, a few words should be said about the botany of these fruits in general.

Botanists have classified the stone fruits into several species. While there has not been entire agreement as to the number of these species, most botanists place them in the great genus *Prunus* in the rose family (Rosaceae); others, however, separate the peach and its close relatives as the genus *Amygdalus*. The fruit develops from a one-celled ovary the wall of which ripens with a fleshy, juicy exterior, making up the edible part of the fruit, and a hard interior, called the stone or pit. The seed is contained in the stony portion.

But while these fruits have enough in common to be grouped in the same genus, they are quite different in many fruit, flower, and tree characters. When the fruits are ripe the flesh of some varieties parts readily from the pit. Such fruits are spoken of as freestones. Other varieties and species, for example, the canning cling type of peaches, are clingstones; that is, the flesh adheres to the stone. The individual fruits may be smooth, as in the apricot, nectarine, plum, and cherry, or hairy, as in the peach. They vary in size, color, and shape

THE *kind of search in which the breeder of peaches is engaged may be illustrated by the Elberta. This is the leading commercial peach in the United States today. It originated in Marshallville, Ga., in 1870, and in the 67 years since that time no better peach has been found, when all characteristics are considered. Yet in quality the Elberta does not rank as high as some other peaches, and the tree and the blossom buds are not sufficiently resistant to low winter temperatures. By suitable crosses, varieties have been developed that have better quality and more cold resistance in the bud; but these in turn are not adapted to so many different growing regions as the Elberta. Again, seedlings of Elberta have been found that ripen earlier than the parent variety and are better in quality and more attractive. It would seem possible, then, to develop a variety that would be a distinct improvement over Elberta, yet possess the valuable characteristics that have given the Elberta preeminence. Such an achievement would be a major contribution to fruit culture in the United States.*

with varieties and species. The flesh may be yellow, green, white, or red, or show various combinations of these colors. The stones or pits of the peach are rough and grooved, those of the plum and cherry relatively smooth, those of the apricot somewhat intermediate.

The flowers of the different stone fruits are quite characteristic for the respective groups. In the peach and the apricot they are borne singly, arising from one to three separate buds at a node. They are practically without stems in the peach, and nearly so in the apricot. They are on long stems in the cherry and on only moderately long ones in the plum, but in both these fruits the flowers are borne in clusters. The flowers of the edible plums are white or nearly so, while those of the peach and the apricot may be white, pink, or reddish.

As will be pointed out later, hybridization between some of the species of stone fruits is practically impossible.

METHODS OF BREEDING

The technique of stone-fruit breeding is not greatly different from that employed with other deciduous fruits. The essential operations are (1) collecting pollen to be used in the crosses, (2) emasculation of the flowers, (3) pollination, or the actual transfer of pollen to the stigmas of the pistil, (4) bagging, or protecting flowers from foreign pollen, (5) protecting fruit that has set, and (6) growing the seedlings for testing and study of the progeny.

Much of the breeding work with stone fruits is carried on with trees growing in the orchard. This has its drawbacks as well as many advantages. Blossom buds, flowers, or young developing fruits may be killed by cold. Under such conditions the continuity of breeding work is interrupted and a year's time is frequently lost. To avoid this difficulty, particularly in the regions of unfavorable climate, it has been found satisfactory to grow the trees in tubs or pots in the greenhouse. Emasculation and pollination can thus be carried on under controlled temperature. Since it is necessary for most stone fruits to have sufficient cold to bring them out of the rest period, the trees in tubs must be removed from the greenhouse in late summer or fall and placed out of doors or in a cool storage place. They may be brought back to the warm greenhouse by the middle of January, and the trees should then bloom in 3 or 4 weeks. While greenhouse trees do not reach the large size of those growing in the field and consequently do not produce as many blossoms, sufficient material can usually be obtained for certain crosses and for genetic and cytological study. In some cases it may be the only way blossoms can be produced for breeding work.

In obtaining pollen to be used in breeding it is usually necessary to collect shoots of the male parents desired and force the blossoms in a greenhouse or warm room in order to have the pollen available when the flowers on the tree are ready for pollination. Care should be taken, of course, that no foreign pollen is introduced by bees or other insects. When the flowers have opened, the anthers may be plucked off by running the filaments through a comb or some similar instrument that will lift off the anthers, which may then be placed in suitable containers to dry at room temperature of 65° to 70° F. When dry they break open and the pollen can be easily crushed out. The pollen should be stored in a dry, cool place in vials or small boxes, from which it may be used directly when the crosses are made. It is convenient to leave a small camel's-hair brush in each container to use in the transfer of pollen.

The structure of the flowers of the peach and other stone fruits permits rapid emasculation. The stamens and the single pistil are enclosed under the folded petals. As the blossom expands from the bud scales, the calyx pushes up, carrying the nonexpanded leafy floral structures, forming a cup around the ovary. The long style of the pistil grows up through the stamens and under certain conditions may even push through between the petals before they expand (fig. 1). In the technique of emasculating, the calyx cup is easily cut with the nails of the thumb and first finger, and the entire corolla with its three rows of stamens attached may be lifted from the flower, leaving the pistil undisturbed. Early workers used sharp-pointed tweezers or scissors to cut the calyx cup, but the fingernail method is more rapid. With varieties of peach that are pollen-sterile, or varieties of plums and cherries that are self-unfruitful, emasculation is unnecessary in ordinary hybridization. A small percentage (0.5–0.8) of set is sometimes obtained in selfing self-unfruitful varieties. While this is a negligible amount in variety breeding, it should not be overlooked in cytological studies.

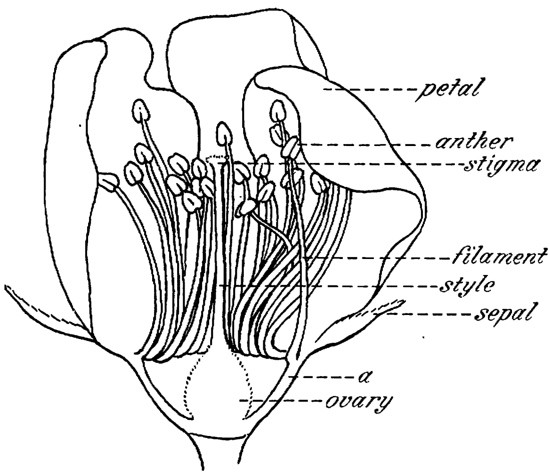

Figure 1.—Section through a peach flower showing arrangement of floral parts. By pinching through the calyx cup at *a* with the thumb and first finger, sepals, petals, and stamens are all removed in one operation, leaving the single pistil.

If emasculation is done just before the petals open (fig. 2)—which is just before any pollen that might cause selfing has been shed—the pollen of the parent to be used in the cross may be applied to the stigmas at once. Where a large number of pollinations are made on a single tree, it is frequently convenient to emasculate all the blossoms before pollinating. With the aid of the camel's-hair brush, from the pollen container a large number of flowers can be pollinated in a short time. Some workers prefer to use the tip of the finger, to which the pollen will adhere, and apply the pollen by touching the stigmas. Care should be taken to remove all pollen grains of one variety or strain from the finger before dipping into a container of another variety. The individual blossoms, single shoots, or entire branches that have been pollinated with a single pollen variety should be carefully labeled with full data on a tag or label that will remain until the fruit is harvested.

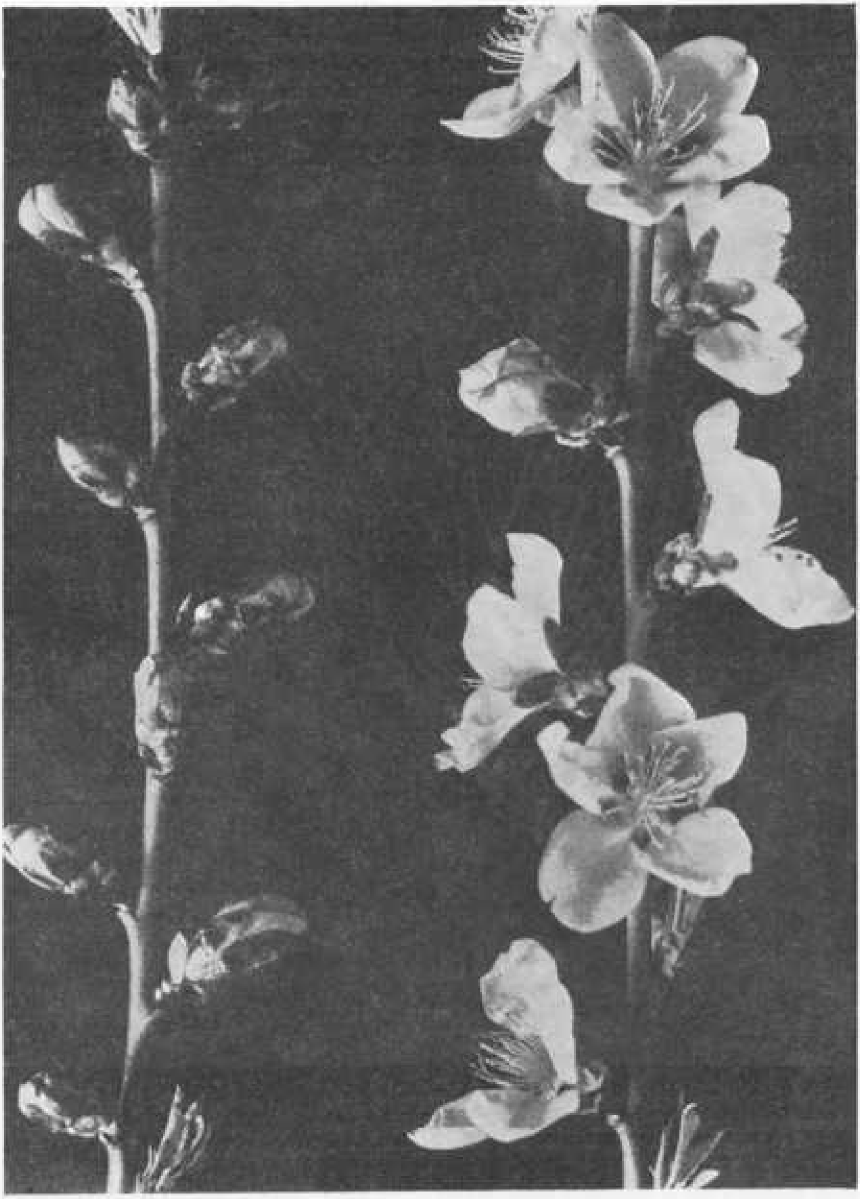

Figure 2.—Flower buds of peach (left) showing ideal stage for emasculation. Within 24 hours with temperatures of 70° to 75° F. the flowers will open as shown on right.

Protecting flowers after pollination is important. The method generally used is to tie a glassine or paper bag over the end of the branch bearing the pollinated flowers (fig. 3). Sometimes two or three flowers may be enclosed in a single bag. With some of the stone fruits, particularly the peach, this method has not been entirely satisfactory, especially where the breeding work is done in the orchard. The relatively long style or stalk of the pistil is easily broken if the bag blows against it (fig. 4) causing loss in bagged flowers. It is necessary, however, to use some method of protection where only a

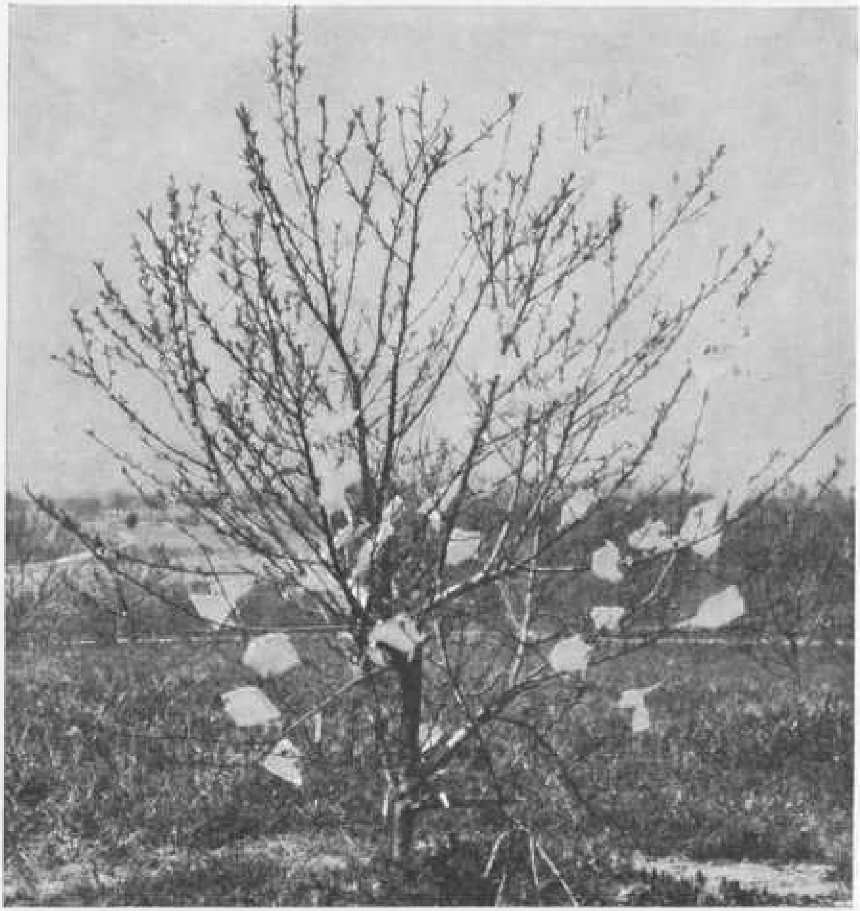

Figure 3.—When only a few blossoms on the tree are to be pollinated it is necessary to protect the flower from foreign pollen. A heavy paper bag or some cover not easily collapsed by the weather is necessary to prevent injury to the pistil.

few flowers on a tree are pollinated. A very heavy grade of paper bag with sufficiently sturdy basal folds to hold the sides out from the flower when the bag is inverted over the branch and tied is desirable to reduce the injury to a minimum. When large numbers of crosses are made, and when no special genetic or cytological studies are undertaken, it is doubtful whether peach flowers need to be protected, particularly if an entire branch or tree has been emasculated. Bees or other insects in visiting the emasculated flowers rarely touch the stigmas and thus do not introduce foreign pollen. If an entire tree is emasculated for a large number of crosses, a tent built over the tree will prove satisfactory not only as a means of protection for the emasculated flowers but for insuring a large set of fruit under unfavorable weather conditions.

After fertilization of the ovules has taken place (fig. 5) and the style begins to darken and wither, the protecting paper bag is removed and an open-mesh bag of coarse cheesecloth or heavy net is placed over the end of the branch to protect the developing fruit. If the fruit drops off at maturity it will be held in the bag. Where the entire tree has been emasculated and tented, or where a number of branches on the tree have been pollinated without bagging, it is necessary to harvest the fruits before they fall.

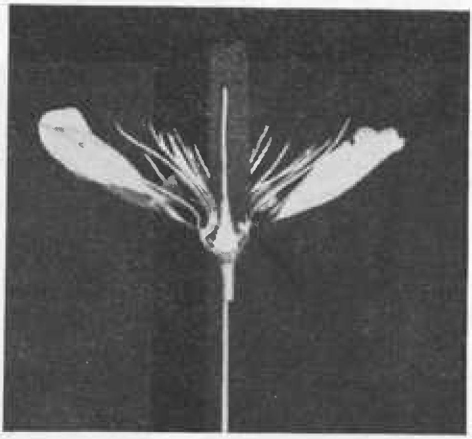

Figure 4.—A peach flower after fertilization, showing the pistil with its long style and the enlarging hairy basal portion, the ovary, which becomes the fruit. In the cherry, plum, apricot, and nectarine the fruit develops similarly from a single hairless ovary.

The stones are removed from the harvested fruit and are allowed to dry in a place free from molds and fungus contamination. Seeds of stone fruits require an after-ripening period of 2 to 3 months at low temperatures before they will grow. They are usually soaked for several hours and then placed in moist sand out of doors during the winter, or, preferably, they may be held for 2 or 3 months in a refrigerator or cold storage at about 40° F.

To insure a high percentage of seedlings in the case of valuable material, the best method is to remove the pits from the cold box, crack them, and remove the seeds. The seed coats are then removed and the young embryos sterilized in hypochlorite solution or some similar disinfectant and placed in small bottles on sterile nutrient agar to grow. When the young seedlings are rooted and a few inches tall, they may be transplanted from the culture bottles to pots in the greenhouse and later removed to the field or nursery row. The more common method of growing the seed is not to remove the seed coat but to plant the seed directly in pots in the greenhouse or in the nursery. Sometimes the pits are not cracked but are planted directly in the field in the fall when out-of-door temperatures will bring about the proper chilling required to insure growth of the seeds in the spring.

A great obstacle in stone-fruit breeding is the difficulty in getting the seeds of some crosses to resume growth. Many hundreds of seeds of crosses of sweet cherry, early-ripening varieties of peach, and other stone fruits have been planted, but no seedlings grew from apparently normal seeds. It is believed that planting the seeds on sterile nutrient agar will be helpful. At the present time, however, there are stubborn seeds of early-ripening varieties of peach and cherry that will not grow even though given the agar-culture treatment. Many such varieties possess desirable characteristics, but they cannot be used as female parents until some method is found to obtain germination of the apparently normal seed they produce.

To economize space the young seedlings are usually planted in test blocks in rows 10 feet apart, with the trees 5 feet apart in the row, which is about as close as cultural operations will permit. At least

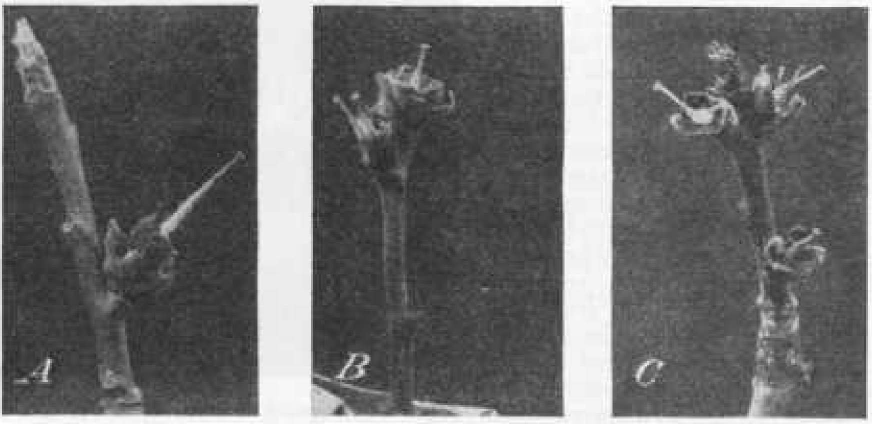

Figure 5.—Peach flowers after emasculation and fertilization. The single pistil (*A*) is normal, but occasionally, in some varieties and under certain nutritional conditions, two (*B*) or more pistils (*C*) may develop in a single flower.

3 or possibly 4 years must elapse before fruit characters can be studied. If it is decided to hasten the fruiting of the progeny, buds or scions can be taken from the seedlings when they are large enough and grafted into branches of bearing trees. In general, budding has proved a more satisfactory method for top-working peach than grafting. In California, however, grafting has proved very satisfactory in the hands of experienced men when dormant scions were placed early in the spring in the cut-back branches of trees 4 to 8 years old. Fruit may be obtained in 2 years from budding, and sometimes in 1 year from grafts. Where tree characters of the seedlings are to be studied, this information is best obtained by leaving them in the field for some years after first fruiting.

Under the most favorable conditions it requires about 5 years from the time the cross is made until a preliminary reading is obtained from the seedling and trees can be propagated for testing in the orchard. If we assume the average life of a peach tree to be about 15 years, then it will be about 20 years before full evaluation can be made of the lifetime merits of a variety. Frequently a much longer time elapses before the value is determined, because of the fact that new varieties are not tested promptly under widely varying soil and climatic conditions.

PEACHES

Early History

The original home of the peach (*Amygdalus persica* L. or *Prunus persica* Batsch.) was thought to be Persia, since this fruit was doubtless introduced into Greece from that country shortly after the beginning of the Christian Era. De Candolle concludes, however, that the peach has never been truly wild in Persia. Botanists agree that the peach is wild in China. The late Frank N. Meyer, explorer of the United States Department of Agriculture, reported finding many wild peaches in China, the fruits of which are inedible, being small and hairy, hard, and with a sourish flesh (*17*).[2] The peach has also long been cultivated in China. It was written about some 2,000 years before its introduction to the Roman world. Reference to the "tao", meaning peach, has been found in the writings of Confucius in the fifth century B. C. and in the Ritual in the tenth century B. C.

There is evidence that the peach reached France and possibly Spain at about the time it was introduced into Greece. From southern Europe it spread to northern Europe, possibly the greatest spread taking place from France. In more recent times France has been an important nursery center, and in the fifteenth and sixteenth centuries nursery trees were sent from France and disseminated through England, Belgium, the Netherlands, and Germany.

Few other fruits are grown under such varied conditions and over such extended areas as the peach. Once a wild inhabitant of China, it is now cultivated in every part of that vast country. Extensive plantings of the peach occur in Turkistan and Persia. It is not surprising, therefore, that early writers regarded Persia as the original home of the peach, as is suggested by the species name *persica* later given it. Peaches thrive in all parts of southern Europe and are grown in sheltered places in the northern latitudes. In the United States the peach found such congenial surroundings that it spread rapidly and widely, leading botanists three centuries later to believe it was native to this country. Today peach varieties are found growing in practically every State of the Union. While the fruit is not grown commercially in regions that are subject to low winter temperatures, some varieties or seedlings are able to withstand the winter temperatures in the colder parts of the country.

Because of the general distribution of the peach in Europe, Asia, South Africa, Australia, South America, and the United States, there has been a general selection of varieties best adapted to the various regions and climatic conditions, as well as to the preferences of consumers. Through this process of selection and hybridization peach varieties with widely differing characteristics have been developed and propagated. Some of the wide differences are so marked that botanists have been inclined to separate the peach into races and, in a few instances, species.

American pomologists (*25*) in the past century tried to divide peaches into four groups or races: (1) The Persian race, brought to North America by the early settlers, best represented by varieties

[2] Italic numbers in parentheses refer to Literature Cited, p. 746.

of the Crawford group; (2) the north China or Chinese Cling race, characterized by large fruits with tender skin and flesh, vigorous tree growth, and abundant and regular bearing, and including such Chinese varieties as Chinese Cling, Chinese Free, and later descendants Belle and Elberta; (3) the south China race, sometimes called

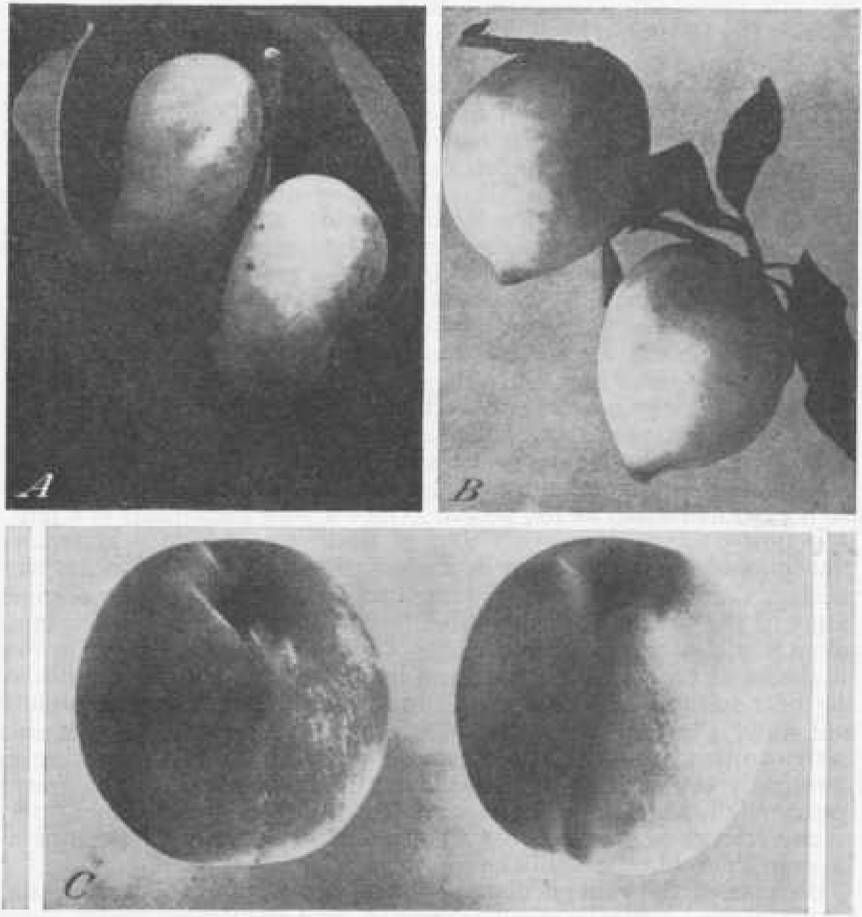

Figure 6.—Shapes of different types of peaches that may be used in breeding: *A*, Peento, or so-called saucer peach of the Gulf States; *B*, the honey peach of Florida and Texas, represented by varieties such as Imperial and Honey; *C*, peach of the Chinese Cling type, representing most of our present-day commercial freestone and canning cling varieties.

the Honey, represented by varieties that bear small, oval to pointed, white-fleshed fruits with a peculiar honey-sweet flavor, and adapted in the United States only to some subtropical sections; (4) the Peento race, a warm-climate type with trees inclined to be evergreen and to bear fruits that are much flattened endwise, white-skinned and white-fleshed, and sweet to very sweet. However, all varieties hybridize freely, and there has been so much crossing between the groups that it is practically impossible to classify many of our present yellow- and white-fleshed varieties on this basis (*16*) (fig. 6).

The nectarine was formerly thought to be a different species from the peach. It is now known that the nectarine is simply a smooth-

Figure 7.—The beginning of commercial peach growing. The early settlers planted fruit trees near the homestead. The home orchard frequently gave place to large commercial plantings.

skin peach. The trees differ in no respect from the peach, and it is impossible to tell a peach tree from a nectarine tree. The leaves are the same. The fruits and seeds have essential characteristics in common. In short, the only difference between the peach and the nectarine is the absence of hairs in the latter. Nectarines are known to have come from peach seeds, and vice versa.

Commercial Peach Growing and Its Stimulus to Variety Improvement

Commercial peach growing in the United States began early in the nineteenth century (fig. 7). Large orchards were planted in Maryland, Delaware, and New Jersey. Prior to this time thousands of peach trees, all seedlings, were planted by growers. Many of the varieties grown in those early years were apparently better suited for making brandy than for general consumption as canned or fresh fruit. While the art of budding and grafting had been known for a long time, it was not until early in the nineteenth century that large commercial orchards of varieties propagated from clons were used.

TABLE 1.—*Fifty varieties of peach grown commercially in the United States during the past 25 years*

Variety	Place of origin	Date of origin	Originator or introducer	Color of flesh	Firmness of flesh [1]	Stone, free or cling	Ripening date [2]	Quality
Admiral Dewey	Vineyard, Ga.	1899	J. D. Husted	Yellow	Soft-melting	Semifree	July 15–23	Good.
Alton	Denison, Tex.	1899	T. V. Munson	White	do	do	Aug. 3–10	Do.
Arp	Arp, Tex.	1897	C. P. Orr	Yellow	do	Semicling	Early	Very good.
Belle	Marshallville, Ga.	1870	L. A. Rumph	White	Melting	Free	Aug. 16–20	Good.
Brackett	Augusta, Ga.	1912	J. P. Berckmans	Yellow	do	do	Aug. 29–Sept. 1	Do.
Carman	Mexia, Tex.	1889	J. W. Steubenrauch	White	Soft-melting	Semifree	July 31–Aug. 5	Do.
Chairs	Anne Arundel County, Md.	1880	Franklin Chairs	Yellow	Melting	Free	Late midseason	Excellent.
Champion	Nokomis, Ill.	1880	I. G. Hubbard	White	Soft-melting	do	Aug. 17–22	Do.
Chili	Chili, N. Y.	1845 (?)	Pitman Wilcox	Yellow	Melting	do	Sept. 8–12	Fair.
Chinese Cling	Shanghai, China	1850	Imported by Charles Downing.	White	do	Cling	Aug. 25–29	Good.
Climax	Florida	1886	G. L. Taber	do	Soft-melting	Semifree	Late	Do.
Crosby	Billerica, Mass.	1876	Mr. Crosby	Yellow	Melting	Free	Late midseason	Do.
Early Crawford	Middletown, N. J.	1820 (?)	William Crawford	do	do	do	Aug. 17–20	Very good.
Early Elberta	Kaysville, Utah	1908	Sumner Gleason, Stark Bros. Nursery.	do	do	do	Midseason	Good.
Early Wheeler	McKinney, Tex.	1906	E. W. Kirkpatrick	White	Nonmelting	Cling	July 11–20	Fair.
Elberta	Marshallville, Ga.	1870	S. H. Rumph	Yellow	Melting	Free	Aug. 21–27	Good.
Engle	Paw Paw, Mich.	1875	C. C. Engle	do	do	do	Aug. 24–Sept. 3	Do.
Eureka	Louisiana	1870	Unknown	White	Soft-melting	Semifree	July 27–Aug. 5	Do.
Foster	Medford, Mass.	1857	J. T. Foster	Yellow	Melting	Free	Late midseason	Very good.
Frances	Texas	1895	L. T. Sanders	do	do	do	Sept. 3–8	Good.
Gaume	Live Oak, Calif.	1913	Louis Gaume	do	Nonmelting	Cling	Late midseason	Do.
Gold Drop	Michigan	Unknown	George W. Griffin	do	Melting	Free	Sept. 8–10	Do.
Greensboro	Greensboro, N. C.	1891	W. G. Balsey	White	Soft-melting	Cling	July 13–18	Do.
Hale Early	Ohio	1850	Mr. Moas. Introduced by Hale and Jewett Nursery.	do	do	Semifree	July 23–28	Do.
Heath Cling	Unknown	1760–70(?)	Unknown	do	Melting	Cling	Sept. 22–27	Do.
Hiley	Marshallville, Ga.	1886	Eugene Hiley	do	do	Free	Aug. 8–14	Very good.
Illinois	North Alton, Ill.	1910	E. H. Riehl	do	do	do	Aug. 17–25	Do.
Iron Mountain	New Jersey	1890	Unknown	do	do	do	Sept. 21–25	Fair to good
J. H. Hale	South Glastonbury, Conn.	1912	J. H. Hale, W. P. Stark	Yellow	Firm-melting	do	Aug. 23–30	Good.
Kalamazoo	Kalamazoo, Mich.	1869	J. N. Stearns	do	Melting	do	Aug. 8–31–Sept. 3.	Do.
Krummel	St. Louis, Mo.	1895	Mr. Krummel	do	do	do	Sept. 23–27	Do.
Late Crawford	Middletown, N. J.	1815(?)	William Crawford	do	do	do	Sept. 5–9	Very good.
Lemon Free	Ohio	1885	Unknown	do	do	do	Sept. 12–19	Good.
Lola	Mexia, Tex.	1876	J. W. Steubenrauch	White	do	Semifree	Medium early	Do.
Lovell	Winters, Calif.	1882	G. W. Thissell	Yellow	do	Free	Late midseason	Do.
Mayflower	North Carolina(?)	Unknown	Unknown	White	Soft-melting	Cling	June 19–30	Fair.
Mountain Rose	Morristown, N. J.	1851	Dr. Marvin	do	Melting	Free	Aug. 16–19	Good.
Oldmixon Free	Unknown	1835	Sir John Oldmixon	do	do	do	Sept. 3–8	Do.
Muir	John Muir farm, Silveyville, Calif.	1890	G. W. Thissell	Yellow	do	do	Aug. 19–25	Do.

Pallas	Augusta, Ga	1878	L. E. Berckmans	White	do	do	Aug. 22-26	Do.
Peento	China	1828	William Prince	do	do	do	Medium early	Do.
Phillips	Sutter County, Calif	1880	Joseph Phillips	Yellow	Nonmelting	Cling	Sept. 12-19	Do.
Paloro	Gridley, Calif	1912	Frank Dixon	do	do	do	Aug. 22-26	Do.
Prolific	Michigan	1890	Greening Bros	do	Melting	Free	Aug. 25-Sept. 1	Do.
Rochester	Rochester, N. Y	1900	Heberle Bros	do	do	do	July 30-Aug. 5	Excellent.
St. John	Unknown	1860(?)	Unknown	do	do	do	Aug. 5-10	Do.
Salwey	Surrey, England	1844	Colonel Salwey	do	do	do	Late	Good.
Stump	New Jersey	1825	Unknown	White	do	do	Sept. 3-8	Very good.
Triumph	Vineyard, Ga	1895	J. T. Husted	Yellow	do	Semifree	July 15-27	Good.
Tuskena (Tuscan)	Mississippi	1873	Unknown	do	Nonmelting	Cling	Early midseason	Do.

[1] The terms "melting" and "nonmelting" are used to denote the degree of softness of the flesh of ripe fruits. All freestones have either firm- or soft-melting flesh, and some early-ripening clingstones (Greensboro) have soft, watery, melting flesh, while the flesh of clingstone varieties of the commercial canning type, such as Phillips, have firm nonmelting flesh.

[2] The ripening dates are those for the U. S. Department of Agriculture orchard at Beltsville, Md., in 1936, a normal season. Where the variety listed did not fruit, the general season is indicated as early or midseason.

As the commercial industry spread, there was always a demand for varieties that would succeed best under various soil, climatic, and other environmental conditions occurring in the different peach-growing sections. In northern regions growers were interested in varieties hardy in wood and bud to withstand low winter temperatures, while in the more southern latitudes they were interested in varieties that would stand summer droughts and high temperatures and with fruit that would retain its firmness during shipment to distant markets. Then came the scourge of disease and insect troubles—peach yellows, leaf curl, brown rot, curculio, and the peach-tree borer. What varieties, if any, would prove most resistant to these troubles?

During the period 1850 to 1900 a large number of varieties were selected from seedlings as worthy of introduction. The list of 50 varieties given in table 1 contains the names of many that still have an important place in the peach sections of the country. They also served as parents for varieties introduced during the last 20 years. The dates of origin of these varieties cannot be accurately obtained in all cases. They are approximately correct and are given to show the length of time the variety has been under orchard test.

It will be noted that the geographical origins of these varieties include nearly all of the States east of the Mississippi between the Great Lakes and the Gulf. Peach growing as an industry was truly widespread in the United States by the end of the nineteenth century. The need for new varieties to replace those that had been under trial was apparent during the period from 1900 to 1910. This was principally due to the fact that peach growing was rapidly developing into an industry for specialists. When the business of peach growing had developed to a point where it was necessary to ship the crop to consuming markets several hundred miles from the orchards, varieties had to be chosen that would stand up in transit and compete successfully with varieties from other sections on the market at the same time. The freeze of 1899 had wiped out many orchards in the North and emphasized the need for varieties that would withstand cold for the commercial orchards of the future. More recent freezes of the winters of 1917–18, 1933–34, and 1935–36 have reemphasized the importance of developing varieties for the North that are more cold-resistant than many now being grown.

Work of Private Breeders in the United States

During the last 30 years there has been an increasing recognition by peach growers of the need of originating new varieties better adapted to meet local requirements in various regions. This is well illustrated by the more recent work of J. W. Steubenrauch, of Mexia, Tex., who developed the Carman variety from pits planted in 1889. It is one of many important commercial peach varieties originated in Texas during the period 1850–1900. Mr. Steubenrauch, now 84 years old, summarized his work in a letter on May 13, 1936.

He planted his first orchard of peaches in central Texas in 1879. There were many kinds available to the growers, mostly what were then called Indian peaches, some good, but not very suitable for general markets. Recognizing the need for varieties of the best quality ripening from early to late season, he bought many trees of new varieties from various parts of the country. In the course of a few years he had 100 or more distinct varieties growing in his orchard. From this number there were not more than about 10 that would be called good varieties for that period, mostly suitable for home use. Among a lot of Elberta trees planted in 1884, he found one tree that he considered superior to all the rest, producing finer fruit more regularly. Having a fine later peach that was part Indian stock, named Belle October, he decided to bud from the fine Elberta and Belle October parents on a single stock away from all other peach trees. From the two varieties blooming together with bees as pollinating agents, he obtained fruit and seeds of the early and late varieties.

Planting the seeds from the best peaches of both varieties, he produced some fine new seedlings in season from the time of Elberta till late in October. One of the leading ones is the Frank, which was named for Frank P. Holland, publisher of Farm and Ranch. This peach bore a heavy crop again in 1936, making 32 years of continuous annual production. Mr. Steubenrauch describes this variety as a fine yellow-red cling, ripening in the middle of August in central Texas.

In addition to the Frank he produced six others that he considers fully as good. These are Tena, Lizzie, Liberty, Anne, Barbara, and Katie.

These varieties, which have been tested in southern latitudes as well as in some of the Northern States, have demonstrated superior germ plasm and are worthy of note for possible use by breeders of peaches.

The man who discovered and introduced the variety that took the lead in commercial peach production in this country from 1910 up to the present was the late S. H. Rumph. He produced the Elberta from a seed of Chinese Cling planted at Marshallville, Ga., in 1870. Curiously enough, another seed reported to have come from the same Chinese Cling tree, planted in the same year by S. H. Rumph's brother, L. A. Rumph, also of Marshallville, Ga., gave rise to the variety called Belle of Georgia. Today these two are still among the leading commercial varieties. They are of particular genetic interest because the Elberta, a yellow, and the Belle, a white, are reported to have come from seeds of the white-flesh Chinese Cling, and because they are promising varieties for use as parents in breeding work.

Hiley, a probable seedling of Belle, originated with Eugene Hiley, also of Marshallville, Ga., in 1886. Today the Hiley variety ranks second to Elberta as the leading peach of the Southeastern States. It has demonstrated its value as a possible parent in peach improvement because of its high quality and its ability to produce fruits in those southern latitudes where warm winters may be a factor in delaying spring growth and blossoming (fig. 8).

One of the most important varieties that became prominent in the period 1900–1920 is J. H. Hale. This variety was discovered by J. H. Hale as a single tree in a lot of Early Rivers peaches shipped to him by David Baird, of Manalapan, N. J., and planted on his farm at South Glastonbury, Conn. Buds from this tree were taken later to Hale's farm at Fort Valley, Ga. Here the variety also showed great promise as a commercial peach, and it was introduced by Hale through the W. P. Stark Nursery in 1912. By 1925 it ranked fourth among the freestone varieties grown for fresh fruit in the United States. Present opinions differ as to its value as a commercial variety. It has most of the essential fruit characters of a good commercial peach, but the trees are somewhat dwarfish on some sites and locations, not particularly hardy in wood and bud, and not highly productive. The flowers are pollen-sterile, a serious fault that affects productivity when the variety is planted in solid blocks. By and large, the variety

Figure 8.—In southern peach-growing latitudes and in regions with warm winters some varieties are much slower than others in coming out of the rest period after mild winters. On the left is a row of Hiley in full bloom, and on the right a row of Early Rose still dormant. Photographed at Marshallville, Ga., April 12, 1932, a year of marked prolonged dormancy for this region. This is about 5 weeks later than average full bloom.

is not as widely adapted nor as productive as one of its probable parents, the Elberta, and it has not displaced that variety from the position of America's no. 1 commercial peach. However, certain characteristics of the J. H. Hale make it of particular interest to the peach breeder and cytologist. Some genetic features of this variety are discussed later in this article.

Hale introduced another variety, the Early Rose, which proved its commercial importance as an early shipping peach for the Southern States. This soft-flesh cling of fair quality and good color was discovered as a chance seedling growing at Fort Valley, Ga., by John H. Baird, of the Hale farm.

Controlled crossing has been carried on by J. E. Markham, of Xenia, Ill., who, beginning in 1925, developed and introduced to the trade Vivid Globe (Yellow Globe × J. H. Hale), Canadian Queen

(Canadian Banner × Early Elberta), Markberta (Halberta × Canadian Queen), Markham Cling (Golden Cling × Jap Cling), Mark Late (Canadian Queen × Markberta), Globe Haven (South Haven × Vivid Globe), Markham Jewel (Imperial Elberta × Canadian Queen), and Halberta (J. H. Hale × yellow seedling). Most of these varieties have not been widely tested.

Private breeders played a very important part in the work of selecting peach varieties of promise not only from a commercial standpoint but also from that of further improvement of the peach by systematic breeding. Space does not permit listing the many individuals who have been constantly on the watch for the appearance of superior sorts originating as chance seedlings and who subjected the seedlings to careful test. The names of many of these men are given in table 1, together with the description of the varieties they introduced.

Peach Breeding at Public Institutions in the United States

Breeding work with peaches was started at the New York (State) Agricultural Experiment Station at Geneva, N. Y., in 1895, when open-pollinated seeds of the Elberta were planted. No crosses were made until 1910. Work was also begun at the Iowa Agricultural Experiment Station in 1905, when the late S. A. Beach planted some selfed seeds of the Chili in an attempt to develop hardy varieties that would prove resistant to cold. Crandall, at the Illinois station, began work on the development of new varieties about 1907. At the same time work was started at the California station on the development of peach varieties that would be satisfactory for growing in the warm climate of southern California. By 1914 several States had provided funds for peach breeding at a number of State institutions. Peach-breeding studies were begun at the New Jersey station in 1914. The present peach-breeding work in Michigan started at the South Haven Horticultural Experiment Station in 1924. The United States Department of Agriculture began cooperation in peach breeding with this State in 1919 and later cooperated in the work in California. By 1930 there was considerable interest in developing new varieties of peaches by systematic breeding, and variety improvement work has recently been started in a number of other States.

The first promising varieties that resulted from this early station work for replacement of unsatisfactory kinds were introduced in 1925 by the New Jersey station and also by the Horticultural Experiment Station at Vineland, Ontario, Canada. A list of new varieties introduced as a result of systematic breeding and selection work by State and Federal agencies and by the Ontario station for the period 1900–36 is given in table 2.

Work is now being carried on at the various State experiment stations to meet special requirements of the peach industry in the several States. Following table 2 is a summary of the crosses being made and the progeny obtained, beginning with States in which the work has been in progress for the longest time.

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Table 2.—*Peach varieties developed and introduced by public institutions*

State or Province	Variety introduced	Parentage	Breeder	When crossed	Year named and introduced
California	Babcock	Strawberry × Peento	Citrus Experiment Station, E. B. Babcock and C. O. Smith.	1907	1933
Iowa	Polly	Chili (selfed, F_2 open-pollinated).	Iowa Agricultural Experiment Station.	1915	1932
Michigan	Halehaven	J. H. Hale × South Haven	South Haven Horticultural Experiment Station.	1924	1932
New Jersey	Ambergem	Belle (selfed)	New Jersey Agricultural Experiment Station.	1914	1934
	Cumberland	Belle × Greensboro	do	1914	1925
	Buttercup	Lola × Arp	do	1916	1925
	Delicious	Belle × Greensboro	do	1914	1925
	Eclipse	Belle (selfed)	do	1914	1925
	Goldfinch	Slappey × Admiral Dewey.	do	1916	1926
	Golden Jubilee	Elberta × Greensboro (open-pollinated hybrid).	do	1914	1925
	Marigold	Lola × Arp	do	1916	1925
	Massasoit	Slappey × Admiral Dewey.	do	1916	1925
	Meteor	Belle (selfed)	do	1914	1925
	Oriole	Slappey × Admiral Dewey.	do	1916	1925
	Pioneer	Belle × Greensboro	do	1915	1925
	Primrose	Belle × Elberta	New Jersey Agricultural Experiment Station.	1915	1925
	Radiance	Belle × Greensboro	do	1914	1925
	Rosebud	Carman × Slappey	do	1916	1925
	Sunbeam	Slappey × Admiral Dewey.	do	1916	1925
	White Hale	J. H. Hale × Belle or Ray.			
	Garden State	Seedling nectarine (self-pollinated).	New Jersey Agricultural Experiment Station.		
U. S. Department of Agriculture.	Maxine	No. 1 Early seedling × Lemon Free.	W. F. Wight	1919	1935
	Leeton	Leader (open-pollinated)	do	1924	1935
	Stanford	Hauss × Phillips	do	1924	1935
	Ellis	Phillips × Linden	do	1924	1935
Ontario, Canada	Vaughan	Leamington (selfed)	Ontario Horticultural Experiment Station.	1913	1925
	Vedette	Elberta (open-pollinated).	do	1915	1925
	Veteran	Vaughan × Early Elberta.	do	1919	1928
	Valiant	Elberta (open-pollinated).	do	1917	1925
	Vimy	Elberta × Arp	do	1916	1925
	Viceroy	Vaughan × Early Elberta.	do	1919	1930

New York

To date 65 varieties, 8 seedlings, and 5 P. I.[3] numbers have been used in breeding work at the Agricultural Experiment Station at Geneva. Champion was used 8 times, Crosby 8, Elberta 27, Greensboro 13, Chili 11, Hunter (nectarine) 19, J. H. Hale 11, Krummel 8, Livingston 12, Rivers Orange (nectarine) 10, Rochester 10, South Haven 10, Sure Crop (nectarine) 31, and Veteran 9. There were in all 333 crosses, 24 selfs, and 13 open pollinations. Of the 400 seed-

[3] Trees imported by the Division of Foreign Plant Introduction as well as seedlings grown from seeds brought in are distributed for testing under numbers preceded by the initials P. I.

lings set in the orchard, 307 have originated from crosses made since 1922. Many of the seedlings are just beginning to fruit, and therefore their full history is unknown.

New Jersey

From the work started in 1914, 20 new varieties had been introduced up to the spring of 1936. In addition to these there are 17 unnamed but specially selected peach seedlings showing considerable promise that are now being grown in State-wide commercial tests During the period 1923 to 1936, 6,257 seedlings had been obtained by crossing, selfing, and open-pollinating varieties of peach and nectarine possessing desirable characteristics. Of this number 1,064 have been retained for further study. Approximately two-thirds of this number are of J. H. Hale parentage.

Iowa

One of the objectives of the breeding work at the Iowa Agricultural Experiment Station is to test the feasibility of making interspecific crosses with stone fruits. About 100 potted trees grown in the greenhouse are being utilized in this work. Varieties of *Amygdalus persica*, including nectarines of *A. davidiana* (Carr.) Zabel as well as hybrids between these two species, are being grown. From the crosses made, approximately 75 promising seedlings are now being studied in the field. These include Chili (fourth generation) open-pollinated, Chili (third generation), Bailey × *A. davidiana*, J. H. Hale × *A. davidiana*, and Chili (third generation) × *A. davidiana*.

Illinois

Of the first series of crosses made by Crandall at the Illinois station all have been discarded except Illinois 146, 148, and 101. These are being propagated for further testing under semicommercial conditions. The quality of all three of these is high, but they probably are somewhat lacking in the firmness of flesh that a commercial peach must possess.

Michigan

From the peach-breeding work begun at the Michigan station in 1924, one promising commercial variety, Hale Haven, a cross of J. H. Hale × South Haven, was introduced in 1932. This is a large yellow freestone maturing 17 days before Elberta and about the same time as South Haven. It is considered to be an improvement over the latter variety because of its higher color, thicker skin, and perfect freestone condition. The number of seedlings being grown at the present time from the crosses made during the period 1924–36 is 2,076. During the period 1924–30, 700 seedlings were obtained from crosses of J. H. Hale with a number of commercial varieties important in Michigan, such as Banner, Kalamazoo, Elberta, South Haven, and New Prolific. Of this list only 15 had superior horticultural value.

Work is now under way in an attempt to develop some clingstone varieties of canning types suitable for Michigan conditions. At the present time there are under observation 359 seedlings from crosses where one parent is freestone and the other cling, or where both parents are cling.

California

The work on peach breeding at the California Agricultural Experiment Station at Davis has been confined in recent years (1930–36) largely to developing a satisfactory type of nectarine for canning. A large number of seedlings are now being grown on the station grounds from about 1,310 crosses of nectarine × nectarine and nectarine × peach. Among the varieties of nectarines used as seed and pollen parents are Stanwick, Ansenne, Diamond Jubilee, Sure Crop, Quetta, Boston, Dixie, New Boy, Goldmine, and Lippiatt. Peach varieties used either as seed or pollen parents in crosses with these nectarine varieties are Lovell, Muir, Late Champion, Red Cling, Elberta, Late Crawford, J. H. Hale, Fay Elberta, and Rochester. In addition there is a very excellent collection of over 300 named and P. I. numbered varieties of peach and nectarine as a source of breeding material.

Breeding work with peaches was begun in 1907 at the University of California Citrus Experiment Station, Riverside, to develop varieties for growing in southern California. In this section many of the older varieties of cling and freestone types do not start growth sufficiently early in the spring to secure normal development, and shedding of blossom buds is common following warm winters. The Babcock peach, which was introduced in 1933 by G. P. Weldon, of the Chaffee Junior College, and by the University of California, was the result of the early work started by E. B. Babcock and C. O. Smith and continued by J. W. Lesley. The special value of the Babcock peach lies in its easily broken dormancy. It is an early white freestone of fair size and good quality. In recent years other crosses have been made, using as seed parents various cling and freestone varieties, and pollen from Honey and Peento types and varieties in which dormancy is easily broken. The Babcock is also being used in these crosses. From this work about 12 seedlings have shown promise and are being carried for further testing. Sims pollinated by P. I. 32374 has given a very promising yellow cling. Sims is a variety characterized by a short rest period.

Massachusetts

Breeding work at the Massachusetts station was begun in 1918. The progeny from most of the crosses made in 1925 and 1926, using as female parents varieties that showed considerable hardiness, has been discarded as unsatisfactory for growth under Massachusetts climatic conditions. There are 2,460 seedlings now receiving special study, mostly of a genetic rather than an immediately practical nature. However, a number of promising seedlings have been selected for further testing. In 1931 and 1932 over 2,000 seedlings were obtained in crosses with Belle, Champion, and Gold Drop in studying the problem of linkage between flesh adherence to stone and flesh texture. Some crosses have also been made in a study of the inheritance of bark color.

Virginia

In recent years studies have been made on the progeny of a smooth-skinned Crawford seedling obtained by selfing, when it was crossed with such varieties as J. H. Hale, South Haven, Rochester, Oriole, Golden Jubilee, Elberta, and Gold Drop. The object of the crosses is to obtain a variety of high quality possessing bud hardiness. Orchard and potted trees are being used. From this work, as well as that previously done with open-pollinated and selfed Elberta, about 15 seedlings of horticultural value have been obtained.

Texas

Breeding studies were begun at the Texas Agricultural Experiment Station, College Station, Tex., in 1935. This work has for its purpose the development of varieties suited to peach-growing districts of Texas where the winter temperatures may not be low enough to give the proper amount of chilling required for best development of varieties that do better in more northern latitudes. Hiley, Pallas, Belle, Early Elberta, Anna, Indian Free, Slappey, and Florida Gem have been used in the crosses.

United States Department of Agriculture

Peach-breeding work in the Department was started in 1919. The early crosses were made at the branch experiment station of the Michigan Agricultural College at South Haven, Mich. Later, crosses were made at the United States Plant Introduction Garden at Chico, Calif. Since 1922 the work has been carried on in the Santa Clara Valley, principally in the experimental orchard at Leland Stanford Junior University, Palo Alto, Calif. Work has recently been undertaken at the United States Horticultural Station at the National Agricultural Research Center, Beltsville, Md., where some 150 varieties are available for study. During the past year 79 separate crosses were made, usually high-quality cold-resistant varieties.

New varieties that have been introduced as a result of the work in California are Leeton, Maxine, Stanford, and Ellis. The Leeton is a selected seedling of Leader grown at Palo Alto from pits imported by Frank Dixon from Leeton, Australia. Maxine is the product of a cross made at South Haven, Mich., between Lemon Free and an unnamed early-ripening seedling of noticeable bud hardiness. The Stanford, a Hauss×Phillips hybrid, is a canning cling peach ripening in season with Phillips. The Ellis, a cross of Phillips×Linden, is also a canning cling type ripening about a week ahead of Stanford. The introduction of these varieties has been based largely upon their behavior under California conditions. The two freestone varieties are worthy of testing under eastern conditions. The Leeton ripens about in season with Triumph and shows promise of being a better early peach than the latter variety. The Maxine is a yellow-flesh variety of high quality, ripening just after Rochester. It has proved to be quite cold-resistant in bud during two recent severe winters (1934–35 and 1935–36) at Beltsville, Md.

A large number of hybrids have been produced since 1922, and these are under test in the experimental orchard at Palo Alto, Calif. Some of the more promising of these hybrids are being tested at other places in California and, in a limited way, in a number of orchards in the eastern United States. Nearly all of the imported freestone varieties produced in this California breeding work are being tested at Beltsville, Md. The seed parents are given in the following list, together with the number of hybrids developed from each parent: Elberta 11, Hauss 5, Horton Rivers×Chili 8, J. H. Hale 11, Illinois 2, Leader 5, Libbee 8, Lovell 7, Maxine 3, Miller Late 2, Mira 1, Muir 15, Newhall 3, Ontario 4, Paloro 18, Phillips 5, Pratt-Low 10, Salwey 44, Selma 3, St. John 2, Tuskena 14, Uneeda 1, Yellow Free 2, Yellow Transvaal 18.

In addition to the more common commercial varieties, a large number of Department introductions having desirable characteristics and showing considerable promise for breeding have been used. Among these are a Chinese introduction (P. I. 43289) and a Spanish cling (P. I. 43570T2). The varieties listed above as female parents have also been used as pollen parents in a good many reciprocal crosses. Backcrosses and intercrosses have also been made with first-generation hybrids. Studies are being made on the progeny of 234 separate and distinct crosses of named varieties and hybrids. From this group of hybrids a number of promising freestone varieties have been obtained that have characteristics superior to a number of the present commercial varieties. Some are promising canning clings, while others show marked resistance to delayed foliation and are adapted for growing in warmer climates where the present commercial varieties do not produce satisfactory annual crops. Combinations have been made between important commercial varieties subject to delay in foliation and such introduced varieties as Yellow Transvaal and St. Helena, which have less prolonged dormancy, in the hope of transmitting this desirable character to the progeny.

In 1909 Shamel and associates (*29*) noted some striking limb variations in studies of freestone varieties in California, and more recently he has discovered some early- and late-ripening strains among peach varieties. Weldon (*31*) has also reported finding several limb variations in orchards in the same State. It appears that some varieties of peach are less stable than others. While very few color sports of peach have been found to date, it would not be surprising if more should be found when careful search is made.

Peach Breeding in Other Countries

Canada

Since 1914 peach breeding has been carried on at the Ontario Horticultural Experiment Station, Vineland, Ontario, to meet the needs of the market and climatic conditions of southern Canada, especially to secure varieties giving a seasonal succession of ripening. Open-pollinated seedlings have been grown in considerable numbers. Some hybridizing has also been done. Earlier ripening Elberta types with attractive fruit of high quality were sought. In all, 13,106 seedlings were grown during the period 1911–36. Of these, 144 have horticultural value. Six varieties were introduced during the period 1925–30. Two of the most promising, Valiant and Vedette, are Elberta seedlings.

From 1918 to 1922 approximately 2,200 open-pollinated seedlings of Elberta were fruited. A second lot of 1,000 Elberta seedlings bore a marked resemblance to the parent tree in growth characteristics and in fruit. Probably 15 to 20 percent could have been propagated and distributed as Elberta, while approximately 3 percent had white flesh, and 15 percent were semiclings or clings. A fair number were moderately good, none exceptional, the majority being of Elberta quality or poorer. The variation in season from Elberta was slight, ranging from a week earlier to a week later. Five hundred and fifty open-pollinated seedlings of Lemon Free were almost identical with the parent. Only a very occasional tree bore fruit with even a suggestion of color other than the yellow. Seedlings of New Prolific, Reeves, and Early Crawford were very much like their parents. The fact that open-pollinated seedlings of peach came so true to type when the pits were taken from an orchard in which there were upward of 150 varieties, thus affording every opportunity for natural crossing, suggests that the peach is usually self-pollinated under orchard conditions.

England

Experiments with peaches and nectarines were begun at the John Innes Horticultural Institution, Merton, England, in 1911. The object was to investigate the genetic composition of fruit trees by raising selfed offspring. The varieties used were Royal George, Blood Leaf, and Lord Napier nectarine. The results obtained will be considered later under the discussion of genetic relationships in the peach.

Australia

The work on production of improved varieties of dessert peaches in New South Wales is located at Hawkesbury Agricultural College, Richmond, while that on improved varieties of canning peaches is at the Yanco Experiment Farm, Yanco. Breeding at the Yanco Farm with peaches was begun in 1928. One of the principal objectives was the development of better varieties for canning that would possess high quality, large size, good yield, and freedom from red around the pit. There is a need for early canning varieties to come in immediately after the late apricots are harvested. Table freestone types are also sought in New South Wales, though not specifically in the breeding program at Yanco. The following varieties have been used in crosses as sources of open-pollinated seeds: Golden Queen, Leader, Paloro, Pullars, Sims, Tuskena, Goodman Choice, Locksley Perfection, and Phillips (Victorian strain). Of these the greatest promise as parents has been shown by Golden Queen, Phillips, Tuskena, and Sims (Victorian). Goodman Choice has desirable habits, and Pullars excels in yield but is red around the pit. Leader, a freestone, is one of the best parents. Dessert types that are being planted for orchard trial are Phillips × Triumph, Tuskena × Leader, and La France × Elberta.

At the Hawkesbury Agricultural College, seedlings of Goldmine (nectarine) × Triumph (peach), Blackburn × Triumph, and Elberta × Wiggins have produced fruit of some promise as freestone dessert peaches. With nectarines, work is under way to improve on the standard variety Goldmine. The varieties used as pollen parents are Mrs. Chisholm, W. C. Frip, and Irrewarra.

Morocco

A fruit and vegetable experimental laboratory was established in 1933 for the study of horticultural genetics. Its activities extend to the six experiment stations of the Lacarelle group, distributed in the different fruit-producing regions of Morocco, as well as to the official experimental gardens of the protectorate. The peach-breeding work has a definite objective, the production of new varieties of high quality adapted to local climatic and soil conditions, as well as stocks resistant to certain diseases, such as gummosis. The work to date has been concerned principally with the study of the hereditary characters of varieties that would appear to be the best parents. A number of hybrids have been produced and are under test. Four forms of the Atlas peach are being used as stocks.

Some Objectives in Improvement of Peach Varieties by Breeding

In surveying the long list of peach varieties available for planting, many are found with very desirable characteristics but for one reason or another not entirely satisfactory from the standpoint of the commercial grower or the home fruit gardener. The fault is often determined by the fruit-growing region in which the particular variety is grown. In one region it may be lack of resistance to winter cold, in another it may be unproductiveness; in still another a peach may prove to be a good bearer with satisfactory cold resistance but lack fruit size and quality. If suitability for canning is the principal requirement in a section, a variety must be judged entirely from this standpoint. Varieties poorly suited for one region or purpose may be entirely suitable for other conditions.

In this article the Elberta has been mentioned as our most important commercial variety, but it lacks some desirable characteristics. It is adapted to a wide range of soil and climatic conditions and is an excellent shipping peach, but it does not have the high fruit quality nor the desired degree of resistance of the tree and blossom buds to low winter temperatures. Where the characteristics of this variety have been combined by breeding with those of a variety more hardy in bud, the results have been promising. A few varieties have been obtained that are of higher quality and more cold resistant in bud than Elberta, but they are not so widely adapted to the fruit-growing regions of this country. Seedlings of the Elberta have been found that ripen ahead of the parent and have fruit of higher quality and more attractive in appearance. So far, when all characteristics are considered, a peach truly better than Elberta has not been found; but if by proper combination of characters a superior variety that is as widely adapted can be produced, it will be a major contribution to American fruit culture. To secure a hardy commercial variety for the colder peach-growing sections of the United States is another most important objective in fruit improvement.

It has long been known that varieties of the so-called Crawford type are of very high quality but not especially productive, and very tender in bud. Varieties of this type have passed out of commercial production because they possessed these unprofitable characters. Attempts should be made to introduce Crawford-type fruit quality or its equal into other varieties, or to combine the hardiness and productive qualities of other varieties with those of the Crawford type. Progress has been made in this direction by using St. John, a Crawford type of high quality but not particularly strong in tree character and cold resistance in bud, in crosses with Admiral Dewey, an old variety that is particularly hardy in bud, with small, fuzzy, unattractive fruits. A very promising hybrid has been thus developed in the breeding work of the Department of Agriculture.

The J. H. Hale variety has many outstanding fruit characteristics, but it is lacking in vigor of tree, hardiness, and productivity. A cross of J. H. Hale × South Haven at the Michigan Agricultural Experiment Station has resulted in a hybrid showing decided improvement over the South Haven variety. Considerable breeding is under way, using the J. H. Hale variety as a parent. Accomplishments to date, while not entirely satisfactory, give promise for the future.

The raw material represented by varieties of peach in this country needs further reworking through breeding methods in order to obtain the desired combination of characters. In this material there are still many important characters lacking that may be found in varieties now growing in other parts of the world. The need of continuing to import material is apparent. An example is the quest for a variety that is not subject to delayed foliation. In climates with warmer winters than those of the fruit regions of this country, varieties are to be found adapted to such conditions. Such varieties should be introduced into this country for combination with our own. Progress has been made in California in recent years on this aspect of breeding work by the Department of Agriculture. Varieties of the peach of the St. Helena and Transvaal types, introduced respectively from the Island of St. Helena and from South Africa and crossed with our native varieties, have given results that would indicate that the problem of delayed foliation can be overcome at least to some extent through breeding.

There is need for more knowledge about the heritable characteristics of rootstocks for peaches. It has been observed that some varieties of a particular parentage are more susceptible than others to cold injury or to root disease. It is important to know which seedlings may be used as stocks to insure longevity, productiveness, and disease resistance. Work is now under way in the Department of Agriculture to determine the merits of seedlings of known varieties of peach and plum suitable for understocks (fig. 9).

As already indicated, methods must be devised whereby the seeds of early-ripening varieties of stone fruits can be made to germinate after crosses have been made.

Another important objective in stone-fruit breeding work is the development of superior varieties for canning and for drying. In California at the present time varieties of apricots suitable for canning are very much sought for. Varieties of peaches of the canning cling type that have been used for a number of years are not entirely satisfactory because of one weakness or another. Some otherwise satisfactory varieties develop red color in the flesh, especially about the pit, which renders them undesirable for canning. Pit splitting and gumming are other faults. Some of the canning varieties used at the present time are susceptible to mildew through the inheritance of glandlessness. Good types lacking such objectionable characteristics are needed for canning.

The method of approach to the problem of developing better varieties will involve basic studies in the inheritance and transmission of characters. An important part of the work, therefore, will be growing and studying progenies to determine the transmission of desirable as well as undesirable characteristics.

Very little work has been done from the standpoint of securing desirable characteristics through induced mutations. Polyploidy, or increase in the number of chromosomes, which has proved of special interest with other crops, has received little attention from workers in

Figure 9.—**Peach rootstock effects. Early Hiley variety, fourth year in the orchard. The row on the right is on plum (*Prunus hortulana*), and the one on the left is on the widely used Tennessee "natural" peach stock. The dwarfing influence on the *hortulana* stock is apparent.**

stone-fruit breeding. Some work has been done at the New York Agricultural Experiment Station at Geneva in an attempt to induce polyploidy in stone fruits through the selection of large pollen grains. This method has not yet yielded satisfactory results, but the studies need to be continued, with many other attacks on the general problem. No results have been obtained so far in attempts to cause mutations through heat treatments, a method that seems promising in corn breeding.

Some Genetic Facts Established in Peach Breeding [4]

In a collection of 100 or more peach varieties selected at random, the casual observer of the trees might think that they are all one variety. Among peach varieties in general there are no very marked differences in general tree characters. There are, however, distinct differences in size, shape, and color of leaves, in time of blossoming, in color and size of flower, in time of ripening, and in fruit characters. Genetic studies

[4] This section is written primarily for students and others technically interested in breeding or genetics.

show these characters to be inherited, and in hybridization many of them appear in the normal Mendelian ratios. Cytological studies to date have not revealed how the factors governing these characters are linked, nor where they are located on the chromosomes, nor what the behavior is in the reduction division of the sex cells.

Connors (*4*, *6*, *7*), of New Jersey, was one of the first workers in this country to investigate some of the genetic relationships in peaches. He made crosses between some of the important commercial varieties in an attempt to gather information on inheritance of characters.

Inheritance of Flesh Characters

Flesh color.—The parents used by Connors in one series of crosses were Elberta and Early Crawford as yellow-flesh varieties, and Belle and Greensboro as white-flesh varieties. Early Crawford has small blossoms, Elberta medium, and Greensboro large. All are freestone except Greensboro, which is a soft semicling. An analysis of the progeny in the F_1 generation showed some interesting facts. All of the varieties used in the crosses were of unknown parentage, having originated as chance seedlings. Belle, a white, and Elberta, a yellow, are supposed to be F_1 descendants of Chinese Cling, with the pollen parent unknown. Greensboro behaved as a pure white in crosses, but when selfed no progeny was obtained because of the failure of the seeds to grow. St. John (yellow) × Early Wheeler (white) gave all white in the F_1, and St. John × Greensboro likewise gave all white F_1 seedlings. White flesh is dominant over yellow flesh. Crosses or self-pollinations of homozygous white-flesh varieties have yielded all white-flesh seedlings. Heterozygous whites have yielded three whites to one yellow. Yellows have given all yellow.

This work makes the supposed parentage of Elberta somewhat open to question. Elberta is a seedling of Chinese Cling, and the pollen parent is thought to be some variety like Early Crawford. If Chinese Cling were pure white, as might be suspected from its early history, then in a cross with a yellow variety the first generation seedlings should all be white. However, Elberta as the F_1 in this probable cross is yellow, while Belle, a seedling of the same variety (Chinese Cling) is white. The Chinese Cling parent of Elberta may not have been a pure white. The work at Vineland, Ontario, Canada, reported by Palmer (*26*), confirms that of Connors in showing that when a homozygous white-flesh peach has been used as one of the parents, all of the progeny will have white flesh. Yellow flesh behaved as a pure recessive. It is perhaps more significant in considering the parentage of Elberta that from 2,200 open-pollinated and selfed seedlings of that variety, there has been none with fruit resembling Early Crawford, the supposed pollen parent. Palmer has ventured the opinion that Elberta is a natural selfed seedling of Chinese Cling, a recessive yellow breeding true for that color.

Texture of flesh.—In the work of Connors, Elberta self-pollinated seedlings showed a high percentage of firm fruit. Wherever Elberta was used as a parent the result was a high percentage of firm-flesh seedlings. Belle × Early Crawford gave a relatively high percentage of firm-flesh seedlings. Soft flesh appears to be dominant over non-melting flesh. The character for producing the tough flesh so desirable for commercial canning is present in Belle, Carman, and Early Crawford. Seedlings of these varieties, however, show red coloring of the flesh about the stone, an undesirable character from a canning standpoint.

Adhesion of flesh to stone.—Connors noted that freestone appears to be dominant over clingstone. In crosses between freestone varieties the progeny has been about two freestones to one cling or semicling. There are some varieties that are classed as semicling in which the adhesion of flesh to stone is not very great. In some of these groups such as Greensboro and Carman, the fruits in some seasons may be nearly free. Frequently, if the fruits are allowed to remain on the tree until well ripened, the flesh will almost completely separate from the stone. The true clingstone type of peach is that represented by varieties like White Heath and Red Bird, and the canning cling by types like Phillips and Paloro. Freestones crossed with freestones always gave a high percentage of freestones, the degree depending on the variety. Belle and Elberta carry a factor for adhesion of flesh to stone of about 33 percent. When freestones are crossed with clingstones a higher proportion of freestones than clingstones is obtained.

Inheritance of Other Characters

Foliar glands or nectaries.—The foliar nectaries of the peach are of interest because it has been shown that glandless varieties are more susceptible to some leaf diseases, particularly mildew, than varieties with glands. Some commercial canning cling varieties now grown in California, such as Paloro and Hauss, are glandless. These are quite subject to mildew in some seasons and in some locations. Rivers (*27*) reports that in crossing varieties having reniform glands with glandless varieties, he obtained an intermediate type, which was round or globose. Connors, in crossing some of our common American varieties, such as Belle, Carman, Elberta, and Greensboro, which are reniform, obtained seedlings all of which were reniform. When these varieties were crossed with varieties with globose leaf glands, the progeny was about 50–50 reniform and glandless. No glandless varieties were selfed, but Bailey and French (*2*) report all the progeny of a selfed glandless seedling were glandless. The F_1 hybrids of a cross between reniform and glandless varieties all have glands that are globose (fig. 10). The character is apparently incompletely dominant.

Tree habit.—In crosses at the New Jersey station between Greensboro, spreading type, and Early Crawford, upright type, the seedlings were all intermediate, none being the same as either parent. Seedlings of Early Crawford, self-pollinated, were all upright. Seedlings of Lola and Carman, which are spreading, were all spreading. The progeny from selfed Elberta gave ratios of 1 upright : 2 intermediate : 1 spreading. No dwarfs have appeared among the progeny of these varieties.

Size of blossoms.—With blossoms the blending type of inheritance is usually shown, with sometimes a slight apparent dominance of the small-blossom type. In all cases studied by Connors, the large blossoms and small blossoms were homozygous. Large crossed with small gave all medium, and the medium split up in a ratio of 1 : 2 : 1 in the F_2 generation. Large blossoms appear to be dominant in varieties bearing them, while varieties with small blossoms give small blossoms in selfing. In crosses of large-petal types with small-petal types all the seedlings had medium-size blossoms. This appears to be a case of incomplete dominance.

Blooming date.—The majority of seedlings bloomed at practically the same season as the parents, but a few individuals bloomed earlier or later. Elberta and Belle, self-pollinated, gave some seedlings that commenced blooming as much as a week after the parents. Slappey is a late bloomer, and all of its progeny were late.

Ripening date.—The hybrids usually ripened about midway between the parents, and it is rarely the case that a seedling ripens

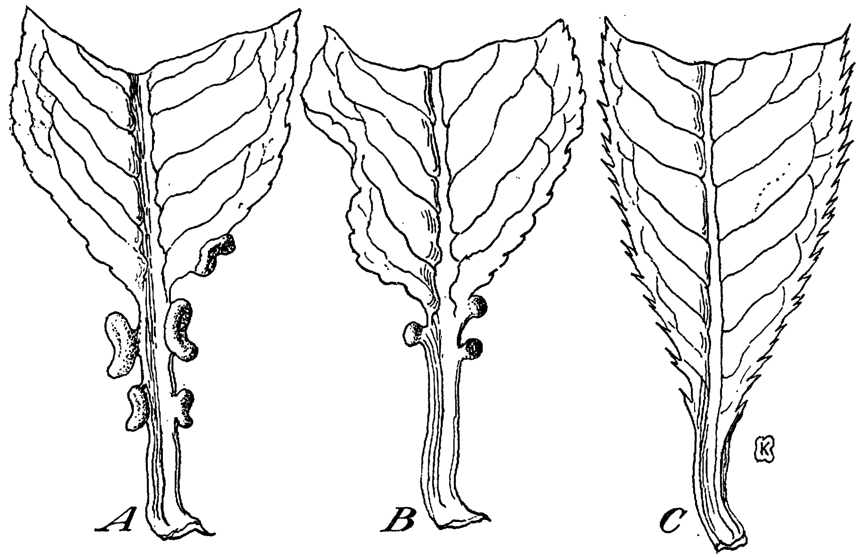

Figure 10.—Types of foliar nectaries in the peach and the nectarine: *A*, Reniform or kidney-shaped glands of Elberta peach; *B*, globose glands of Fitzgerald peach; *C*, eglandular leaf of Lippiatts nectarine.

earlier than the early parent or later than the late parent. The deduction is that the best chance to secure a new individual ripening its fruit at a certain date would be by crossing two varieties the mean of whose ripening dates would fall at the desired time. No marked differences in ripening dates were observed. The majority of the seedlings of the varieties used ripened about in season with the parents, with some slightly earlier and some later than either parent.

Size of fruit.—Parents with small-size fruit are to be avoided. Belle transmitted its character for good fruit size. Elberta seedlings are practically all large-fruited.

Beginning in 1921, Connors used the J. H. Hale variety in a number of crosses. During the period 1923–28, 42 crosses were made with this variety. Blake and Connors (*4*), reporting on the results of these crosses, state that the collection of characters in the J. H. Hale variety was as a group recessive to the characters in varieties such as Chili, Iron Mountain, Chinese Blood, and varieties with nonmelting type of flesh. In the case of J. H. Hale × Chili the progeny of the cross so closely resembled Chili in every way that it was impossible to distinguish many of them from the pollen parent. In summarizing the evidence of inheritance of characteristics in the progeny of these J. H. Hale crosses, Blake and Connors drew the following conclusions: (1) Red flesh color about the pits is apparently dominant over absence of red at the pit; (2) watery melting flesh texture is apparently dominant over firm-melting flesh texture; (3) nonmelting flesh is recessive to both watery melting and firm-melting flesh texture; (4) blood red flesh was dominant over the absence of red; (5) heavy pubescence is apparently dominant over short or light pubescence; (6) oval-conic, oval-oblong, and round-pointed forms in Chili, Iron Mountain, Chinese Blood, Japan Dwarf Blood, and others were dominant over round; (7) full-dwarf and semidwarf growth habit was recessive to standard tree size; (8) early blooming, characteristic of *Amygdalus kansuensis* (Rehd.) Skeels, was dominant over the late blooming of J. H. Hale; (9) vigorous sucker development from the trunk and main branches characteristic of *A. kansuensis* was dominant over the slight sucker development of J. H. Hale.

Characters Transmitted by Certain Varieties

Elberta transmits large fruit size, yellow color, and firmness of flesh, freestone character, an extended period of ripening, and a slight tendency to sterility. The self-pollinated seedlings show better quality than that of the variety itself.

Belle is a heterozygous white and is able to transmit white and yellow flesh, a fair degree of firmness of flesh, a fair degree of freestone condition, variability in period of ripening and blooming, and a tendency to sterility.

Early Crawford transmits small fruit size, yellow flesh, a good degree of firm or tough flesh, a fairly high degree of freestone character, tender pubescent skin, and rather high acidity.

Greensboro transmits white flesh, good fruit size and color, hardiness in bud, softness of flesh, and a clingstone character.

Slappey transmits small fruit size, dry, mealy, yellow flesh, lateness of blooming, and nonadhesion of pulp.

Lola transmits small size, tendency to clingstone condition, and tough flesh.

In tree habit the white-flesh varieties are more vigorous in tree growth than yellow-flesh sorts.

Further genetic studies on the inheritance of characters in the peach may be helpful in tracing the origin of the aforementioned groups or races of peaches. This should be possible if prototypes of our present-day varieties could be located, such as the large-petaled, white-fleshed peaches of China, and the small and medium-petaled, yellow-fleshed types found among varieties more common in western Asia and the Mediterranean countries, and among the varieties now commonly grown in this country.

Genetic Studies in England

Work at the John Innes Horticultural Institution in England with the peach Royal George, having small flowers and small, eglandular, serrate leaves, when selfed gave a progeny of seedlings with small flowers and eglandular, serrate-margined leaves. Royal George and its progeny proved to be susceptible to mildew.

The Purple Leaf variety of peach (Blood Leaf) with large flowers, purple leaves, reniform glands, shallow margin, finely serrate, when selfed gave a small number of progeny, all having large flowers, purple leaves, reniform glands, and leaf margin similar to type.

Selfed nectarine (Lord Napier variety) with large flowers, large leaves, reniform glands, and shallow crenate margin gave seedlings with flowers and leaves similar to the parent. A few of the leaves were almost serrate.

Two seedlings raised from a cross of Purple Leaf peach × Lord Napier nectarine had purple leaves, but the pigment was less intense than in the Purple Leaf parent or its selfed derivatives. This suggests that the purple pigment in the peach behaves as a dominant, but the reduction in the amount of pigment suggests a modifying factor.

Correlations

Hedrick (*17*) has pointed out a correlation between color of the inside of the calyx cup and the color of flesh of the fruit. When the calyx cup is greenish the fruit will be white, and when the calyx cup is a deep orange the flesh of the fruit will be yellow. An intermediate type is suggested by Connors in which the calyx cup is yellowish buff, and following this the color of the flesh will be white, but the tree carries a character for yellow flesh. This is true in the case of Belle.

Another correlation, according to Connors, is that between leaves and the color of the flesh. When the midrib and the veins of the leaves of a variety have a yellowish cast the fruit is yellow, but if the midrib or veins are pale green or whitish the fruit will be white.

Pollen Sterility

Most varieties of peaches are self-fruitful. Occasionally failure to produce crops may be due to pollen sterility, which is exhibited in a few commercial varieties, such as J. H. Hale, Halberta, Candoka, Mikado, and Chinese Cling.

Connors in 1921–22 examined over 330 seedlings in the fruit-breeding plots. J. H. Hale was the only variety that did not produce pollen, and about 50 percent of open-pollinated seedlings of this variety were pollen-sterile individuals. Progeny of some crosses with J. H Hale have also shown about 50 percent of sterile individuals, while in other crosses with this variety the progeny all produced pollen. It is suggested that this type of sterility is recessive to the fully fertile flower form. The failure of pollen-grain development in J. H. Hale has been found to be due to degeneration in the microspores some time previous to blossoming. Apparently there are strains of this variety that produce pollen and are self-fruitful, but whether these have arisen as somatic variations or have distinct ancestry is unknown.

Among seedling peach progenies examined the percentages showing pollen sterility were: Belle selfed 21 percent, Belle × Elberta 17, Elberta × Belle 14, Elberta selfed 13, Elberta × Early Crawford 7, Elberta × Greensboro 5, and Belle × Greensboro 4 percent.

Chromosome Numbers in Peach Varieties

The basic chromosome number in the sex cells in the genus *Prunus* is 8. The varieties of peach examined cytologically show the diploid ($2n$) number of chromosomes to be 16. So far as known, no triploid or tetraploid types have been discovered. If these have occurred in the past they have apparently not been propagated or were discarded in the search for new varieties. The fruit characteristics of the J. H. Hale variety might suggest a tetraploid condition, but insofar as is known they are not associated with tetraploidy.

The peach is rather a stable entity. No irregularities in chromosome behavior have been reported. Apparently reduction to the haploid number in the formation of the sex cells prior to fertilization and fruit development proceeds in a normal manner. Likewise in somatic cell divisions no conspicuous irregularities have been reported in chromosome behavior, and few varieties have been propagated as true somatic mutations.

The problem of self-unfruitfulness, which is very important in the case of other stone fruits and of apples, and which has stimulated considerable cytological investigation with these fruits, is relatively unimportant in the peach.

Nearly all of our commercial varieties are self-fruitful, that is, they set fruit with their own pollen. In a few instances varieties are self-unfruitful because of pollen sterility.

Our present-day varieties are largely considered to be chance seedlings, and many of them may have arisen as self-pollinated progeny of various types. Some doubtless are the result of natural hybridization. It is a fact, however, that many of these varieties are homozygous for the genes controlling several of the characters studied.

Appendix (Peach)

Table 3.—*Locations of peach-breeding work and names of workers in the United States and Canada*

State or Province, institution, and location	Year work was begun	Early workers	Workers actively engaged at present
California:			
Agricultural Experiment Station, Davis.	1925		W. A. Tufts, G. A. Philp.
Agricultural Experiment Station, Riverside.	1907	E. B. Babcock, C. O. Smith, H. B. Frost.	J. W. Lesley.
Chaffee Junior College, Ontario			George P. Weldon.
U. S. Department of Agriculture, Palo Alto.	1922		W. F. Wight, L. A. Thompson.
Illinois:			
Agricultural Experiment Station, Urbana.	1907	C. S. Crandall	J. C. Blair, M. W. Dorsey, J. C. Whitmire.
Iowa:			
Agricultural Experiment Station, Ames.	1900	S. A. Beach	T. J. Maney.
Maryland:			
U. S. Department of Agriculture, Beltsville.	1931		F. P. Cullinan, J. H. Weinberger.
Agricultural Experiment Station, College Park.	1929	E. C. Auchter, W. L. Kerr.	A. L. Schrader, S. W. Wentworth.
Massachusetts:			
Agricultural Experiment Station, Amherst.	1918		J. S. Bailey.
Michigan:			
Agricultural Experiment Station, South Haven.	1924		Stanley Johnston, V. R. Gardner.

TABLE 3.—*Locations of peach-breeding work and names of workers in the United States and Canada*—Continued

State or Province, institution, and location	Year work was begun	Early workers	Workers actively engaged at present
New York:			
Agricultural Experiment Station, Geneva.	1895	S. A. Beach	U. P. Hedrick, R. Wellington, Olav Einset.
New Jersey:			
Agricultural Experiment Station, New Brunswick.	1914	C. H. Connors	M. A. Blake.
Texas:			
Agricultural Experiment Station, College Station.	1935		S. H. Yarnell.
Virginia:			
Agricultural Experiment Station, Blacksburg.	1925		Fred W. HofMann.
Ontario, Canada:			
Horticultural Experiment Station, Vineland.	1914		E. F. Palmer, G. H. Dickson.

Peach and Nectarine Breeding Material at the United States Horticultural Station at the National Agricultural Research Center, Beltsville, Md.[5]

PEACHES

Admiral Dewey
Admiral Dewey × St. John
Alexander
Alton
Australian Saucer
Babcock
Banner
Barnard
Belle
Beers Smock
Berk Favorite
Best June
Bilyeu
Blood Flesh
Brackett
Briggs Red May
Canadian Queen
Candoka
Captain Ede
Carman
Chili
Chinese Cling
Champion
C. O. Smith
Cumberland
Curry
Delicious
Duke Hale
Early Crawford
Early Elberta
Early Imperial
Early Queen
Early Rose
Early Wheeler (Red Bird)
Eclipse
Elberta
Elberta × Phillips
Engle Mammoth
Eureka
Fairs Beauty
Father's Pride
Fay Elberta
Fitzgerald
Fei
Flaming Gold
Fox
Frances
Gage
George IV
Giant Snowball
Globe
Gold Drop
Gold Finch
Golden Jubilee
Greensboro
Halberta
Halehaven
Hale Early
Hauss × Foster
Heath Cling
Henrietta
Hiley
Hobson
Honey Dew
Hope Farm
Horton River
Hyslop
Illinois
Improved Crawford Late
Indian Blood Cling
Iron Mountain
Japanese Giant Cling
J. H. Hale
John Rivers
July Elberta
July Gold
June Elberta
Kalamazoo
Kathryn
Kette
Krummel
Late Crawford
Leeton
Lemon Cling
Lemon Free
Levy
Libbee
Linworth
Lovell
Loving Cling
Luken Honey
Mammoth Heath Cling
Marigold
Mark
Markham Cling
Marquette
Martha Fern
Mathews
Maxine
Mayflower
Mikado

[5] The variety names in this and the following lists conform so far as practicable to the code of fruit variety nomenclature. However, among them there is a considerable number of introductions from other countries, selected strains of standard varieties tentatively designated, and other names applied temporarily, which cannot be made to conform readily to the code. The publishing of such names in this connection is not to be construed as the acceptance of them by this Department.

138904°—37——45 ++

Miller Late
Minnie Stanford
Mountain Rose
Muir
Newcomb
Newhall
New Jersey 71
New Jersey 73
New Jersey 87
New Prolific
Niagara
N. J. 12722
Oldmixon Cling
Oldmixon Free
Opulent
P. G. W.
P. I. 36126
P. I. 43137
P. I. 68353
P. I. 101655
P. I. 101663
P. I. 101665
P. I. 101667
P. I. 101668
P. I. 101669
P. I. 101675
P. I. 101676
P. I. 101677
P. I. 101680
P. I. 101681
P. I. 101682
P. I. 101687
P. I. 101688
P. I. 101689
P. I. 43289 × Early Crawford
Pallas
Peacharine
Peak Cling
Phillips
Pickett Favorite
Pioneer
Polly
Pratt Low
Ray
Red Indian
Rio Oso Gem
Roberta
Rochester
Radiance
St. John
Salberta
Salwey
September Mammoth
Shalil (P. I. 63852)
Shippers Late Red
Sims
Slappey
South Haven
Stinson
Strawberry
Stump
Sun Glo
Texan
Triumph
Uneeda
Valiant
Vedette
Veteran
Viceroy
Vivid Globe
White Cling
White Hale
Wilma
Yellow Indian

NECTARINES

Boston
Gold Mine
Gower
Hunter
Lipiatt Late Orange
Quetta
Rivers Orange
Stanwick
Sure Crop

Peach and Nectarine Breeding Material at the California Agricultural Experiment Station, Davis, Calif.

PEACHES

Admiral Dewey
Al
Alexander
Alpha Tuscan
Alton
Amsden
Angel
Annabel
Arp
Australian Saucer
Babcock
Banner
Barbara
Belle
Belle October
Best June
Bitterless Elberta
Bilyeu
Blood
Blood Cling
Blood Free
Blood Leaf Cling
Bokhara
Bolivian Cling
Brackett
Bresquilla
Briggs
Brock Beauty
Buckhorn
Burton's Hale Early seedling
Cameo
Captain Ede
Carman
Carota
Carpenter
Champion
Chiloro
Cumberland
Cotogna di Siena
Crimson Cling
Cuban Nut
Currie Free
Dahling
Day Late Cling
Decker
Dorothy
Duchess of Cornwall
Earliest
Early Charlotte
Early Crawford
Early Elberta
Early Imperial
Early Japanese
Early Rose
Early Wheeler
Elberta
Elberta Cling
Estella
Eureka
Everbearing
Fay Elberta
Fei
Fitzgerald
Florida Gem
Florence
Foster
Frank
Frank seedling
Fredericka
Gaume
George IV
George Late
Gibbon October
Gilla Tardiva di Milano
Gillingham
Globe
Gold Dust
Goodman Choice
Golden Chinese
Golden Jubilee
Golden Sweet Cling
Golden Queen
Greensboro
Grosse Mignonne
Haight Late Free
Hale Cling
Hale Early
Harris
Harris Yellow Cling
Halford No. 1
Halford No. 2
Halford No. 3

Heath Cling
Helen
Hobson
Home Freestone
Honey
Honey Cling
Ideal
Ijam Tuscan
Illinois
Imperial
Japan Dwarf
Jewel
J. H. Hale
J. H. Keith Early May
Johnson
June Elberta
Katie
Klondike
Krummel
Lady Lindsey
Lady Palmerston
La Grange
Late Champion
Late Crawford
Late Elberta
Late Tuscan
Leader
Lemon Cling
Leona
Levy
Libbee
Liberty
Lippiatt
Lovell
Luken Honey
Mammoth Heath
Massasoit
Mary
Mayflower
McDevitt Cling
McKevitt
Miller Late
Ming Tomb
Minnie Stanford
Mississippi
Monte Vista Cling
Morellone
Morris White
Mother
Motions Cling
Mothers Favorite
Mountain Rose
Mowry Strawberry Cling
Muir
Muir Perfection
Munford
National
Newcastle Tuscan
Newhall
New Jersey
Niagara
Nichols
Noble Red
October Beauty
October Indian
Octoberta
Oklahoma Beauty
Oldmixon Cling
Oldmixon Free
Ontario
Opulent
Orange Cling
Oriole
Osprey
Pallas
Paloro
Paragon
Patison
Peak
Peento
Peregrine
Perfection
Phillips
P. I. 24807
P. I. 32374
P. I. 35201
P. I. 36485
P. I. 41395
P. I. 43289
P. I. 43290
P. I. 43291
P. I. 55563
P. I. 55564
P. I. 55813
P. I. 55835
P. I. 61302
Picquet Late
Pinkham
Placer Cling
Pomona
Pratt Low
Prince of Wales
Pullar Cling
Radiant
Raisin Cling
Radiance
Red Bird (synonym of Early Wheeler)
Rio Oso Gem
Rochester
Runyon Orange Cling
Red Muir
Sabichi Winter
St. John
Salwey
Sea Eagle
Sellers
Selma
Shamrock
Shalil seedling
Sharpe
Sherman
Shippers Cling
Sims
Smith
Smith Indian
Sneed
Stearns
Stinson
Strawberry
Summer Heath
Sunbeam
Sullivan
Stump
Suber
Susquehanna
Sutter Creek
Taylor
Tena
Texas
Thurber
Thurmond
Togo
Tosetti Late Free
Triana
Tribbles Cling
Tribbles Free
Tribbles Price
Triumph
Tuscan (synonym of Tuskena)
Tuskena
Up-to-Date
Vainqueur
Van Emmon
Vivid Globe
Victor
Waldo
Walton
Ward Late
Washington
West Late Free
Wilbur
Wiley Cling
Wilma
Winter Freestone
Worth
Yellow Hiley
Yellow Swan

NECTARINES

Advance
Ansenne
Boston
Breck
Cardinal
Davis
Diamond Jubilee
Dixie
Downton
Dryden
Early Newington
Early Rivers
Fisher Yellow
Gaylord
Gold Mine
Gower
Griffith
Hardwiche

Humboldt
J. C. Wees
Kathryn
Lippiatt
Lord Napier
Mexican
Milton
Muir
Nettarino Gilla d'Padova
New Boy
New White
Nigh
Newton
Ozark
P. I. 26503
P. I. 29227
P. I. 30648
P. I. 65973
P. I. 65974
P. I. 65975
P. I. 65976
P. I. 65977
P. I. 65978
P. I. 65979
P. I. 68178
Pineapple
Quetta
Red Cling
Red Roman
Robinson
Smith
Spanish
Spencer
Stanwick
Stanwick Elrudge
Surecrop
Togatch Moneck
Traveller
Victoria
Violet
Wilkinson

Peach and Nectarine Breeding Material at the Georgia Agricultural Experiment Station, Experiment, Ga.

PEACHES

Admiral Dewey
Alton
Annabel
Belle
Babcock
Banner
Best June
Best May
Brackett
Chilow
Chinese Cling
Cumberland
Delicious
Eureka
Early Rose
Eclipse
Elberta
Fertile Hale
Fitzgerald
Florida Gem
Gage Elberta
Georgia Hale
Golden Jubilee
Goldfinch
Halehaven
Hale seedling
Harpole Late Yellow
Honey
Indian Blood
Jewel
J. H. Hale
Kette
Krummel
Lemon Free
Luttichau
Manly
Marigold
Marquette
Mayflower
Mikado
Mountain Rose
New Jersey 46–B
New Prolific
Oriole
Paloro
Paloro No. 2
Picquet Late
Phillips No. 1
Pioneer
Rio Oso Gem
Riverdale
Rochester
September Mammoth
Shipper Big Red
Sims
Slappey
Sunbeam
Sun Glo
Tuskena (Tuscan)
Valiant
Vedette
Veteran
Walton
Weem Hale
White English
Willow Leaf
Wilma
Woodland Cling

NECTARINE

Red Roman

Peach and Nectarine Breeding Material at the New Jersey Agricultural Experiment Station, New Brunswick, N. J.

PEACHES

A–1 on Salwey Seedling (43124)
Admirable Jaune (P. I. 86168)
Admiral Dewey
Agostina (80128)
Aicken Cling (P. I. 88543)
Alberge Jaune (P. I. 101820)
Amarillo Tardio (P. I. 55835)
Amarillo Tardio (P. I. 55836)
Ambergem
Ames 2
Anna
Arp
Augbert
Aurora (P. I. 57688)
Australian Saucer
Banner
Barbara
Beauty Belle
Belle de Vitry (P. I. 102515)
Bennetts Perfection
Berks
Best June
Bilmeyer
Bolivian (P. I. 36126)

Brackett
Briggs Early May (synonym of Briggs)
Burbank
Burbank Giant Freestone
Buttercup
Camelliaflore
Candoka
Chairs Choice
Charles Ingouph (P. I. 101825)
Chili
Chinese Blood
Chinese Cling
Clam Shell Elberta
Colora
Columbia
Connett
Crosby
Cumberland
D. B. Ansac (P. I. 88546)
Delicious
D'Italia
Double Pink
Double Red Early
Double White
Duke of York
Dulce
Eagles Beak (P. I. 43289)
Early Crawford
Early Elberta
Early May
Early Rose
Early Wheeler
Eclipse
Elberta
Elberta Dwarf
Engle Monmouth
English Galande
Estella
Eureka
Exquisite
Fertile Hale
F. H. B. (43051)
Fitzgerald
Foster
Fox
Frances
Frank
Fredericka
Gallande (P. I. 66094)
Gemmer
General Lee
George IV
Gold Drop
Golden Elberta Cling
Golden Gem
Golden Heath
Golden Jubilee
Goldfinch
Goodman Choice on Salwey (68354)
Gordon
Goshawk
Greensboro
Grosse Mignonne (P. I. 76357)
Grosse Mignonne (P. I. 91763)
Grosse Mignonne (P. I. 102523)
Halberta
Hale Early
Halehaven
Hann Almond
Hardee
Harpole Late Yellow
Hauss
Heath Cling
Hiley
Hobson
Hope Farm
Ice Cream
Ideal
Illinois
Indiana
Indian Blood Cling
Indian Cling
Iron Mountain
Isquierdo (P. I. 57687)
Japan Dwarf Blood
Japan Golden Giant Cling
Jennie Worthen
J. H. Hale
J. M. Mack
July Elberta
July Gold
June Elberta
Kalamazoo
Kathryn
Katie
Kette
Kihi Kihi (P. I. 88547)
King Solomon
Krummel
Late Champion
Late Crawford
Late Elberta
Leeton
Lees Salwey (P. I. 88548)
Lemon Cling
Lemon Free
Leona
Lizzie
Lippiatt Late Red
Madeleine de Courson (P. I. 66095)
Mamie Ross
Marigold
Marquette
Marriages Late (P. I. 88550)
Massasoit
Maxine
Mayflower
Mexican Honey
Mitchelson (P. I. 88551)
Monkton No. 1 (P. I. 88552)
Monkton No. 2 (P. I. 88553)
Morris White
Motions Cling
Mountain Rose
Muir
Muir Perfection
National
Ohio Late Crawford
Oldmixon Free
Oriole

Pallas
Paloro
Pomona Majorada (P. I. 57689)
Paragon
Prunus davidiana
Peacharine
Peento
Phillips
P. I. 35201
P. I. 36485
P. I. 55564
P. I. 55775
P. I. 55776
P. I. 55885
P. I. 55886
P. I. 55887
P. I. 55888
P. I. 56920
P. I. 61302
P. I. 63850
P. I. 63851
P. I. 63852
P. I. 63853
P. I. 63855
P. I. 74011
P. I. 76202
P. I. 76361
P. I. 88562
P. I. 88561
P. I. 91762
P. I. 92159
Pioneer
Plummer (P. I. 88565)
Polly (Ames 11)
Poppa de Venere (P. I. 102527)
Primrose
Prunus kansuensis
Prunus mira
Pullar Cling
Purple Leaf
Radiance
Ray
Red A
Red B
Red C
Red D
Red Bird (synonym of Early Wheeler)
Reeves
Reina Eleana (P. I. 57690)
Red Magdelaine (P. I. 57691)
Rio Oso Gem
Rochester
Rosebud
Salberta
Salwey
Sant Anna (P. I. 102530)
Sargents
Sellers Orange
Semi-Dwarf Elberta
September Monmouth
Shippers Cling
Shippers Late Red
Slappey
Sleepers Dwarf
Smock
South Haven
Stevens
Stinson
St. John
Strawberry Free
Stump
Sunbeam
Sun Glo
Sungold
Surprise
Tos China (P. I. 77877)
Tos China on Salwey (P. I. 77878)
Tos China on Salwey seedling (P. I. 77876)
Triumph
Tuskena (Tuscan)
Up-to-Date
Valiant
Vanity
Veteran
Vidette
Volaric (P. I. 107783)
Waipawa on Salwey seedling (88556)
Waldo
Watt Early (P. I. 57917)
White Hale
Wilma
Winner
Wm. Kane
Wrights Bountiful (P. I. 88567)
Wrights Late Red (P. I. 88558)
Wrights Midseason (P. I. 88559)
Yellow Greensboro
Zelandia Peach (P. I. 88560)

NECTARINES

Blood Fleshed
Breck
Cardinal
Diamond Jubilee
Flaming Gold
Garden State
G. O. Breeding
Goldmine
Gower
Humbolt
Lippiatt Late Orange
Nectarine Peach (P. I. 88554)
Littles Yellow
Lord Napier
P. I. 65973
P. I. 65974
P. I. 65975
P. I. 65976
P. I. 65977
P. I. 65978
P. I. 65979
Pineapple
Sure Crop
Victoria
Yennman

PLUMS

In the United States, as well as in Europe, the plum has long been recognized as one of the most delicious of fruits, and among the stone fruits it ranks next to the peach in commercial production. Many of the varieties of plums now cultivated in the United States have been introduced from many foreign countries, and when these are added to the native varieties they give plums the largest number and greatest diversity of kinds and species among the stone fruits. The fruits exhibit a wide range of size, flavor, color, and texture. The plants vary from small shrubs with drooping branches to trees of large size with large, upright branches, and some have great beauty as ornamental plants (*3*, *19*, *34*).

The common European plum, known botanically as *Prunus domestica* L., appears to have originated somewhere in southeastern Europe or western Asia, probably in the region around the Caucasus and the Caspian Sea. Although it is called the European plum, De Candolle, who summarized the history of these stone fruits, is very doubtful whether *P. domestica* is indigenous to Europe. According to the earliest writings in which this plum is mentioned, the species dates back some 2,000 years. Another Old World plum species, probably of European or Asiatic origin, is the damson plum, *P. insititia* L. This species seems to antedate *P. domestica*, as is suggested by the finding of damson plum pits in ancient ruins. The ancient writings connect the early cultivation of these plums with the region around Damascus.

It is not known just when European plums were introduced into North America, but probably pits were brought over by the first colonists. It is reported that plums were planted by the Pilgrims in Massachusetts, and importations were made by the French into Canada. These European plums have done remarkably well in the New World, and today they constitute the most important group grown commercially for canning and drying.

The native American plums were doubtless used for food by the Indians long before the white man set foot on the shores of this continent. Reports of early explorers mention the finding of plums growing in abundance. According to the descriptions of the early settlers, these plums were inferior to the domesticas of the Old World in quality, so that the colonists soon began importing varieties from Europe. As a result, European plums soon became predominant in home fruit gardens as well as commercial orchards in the northeastern United States.

Another important species of more recent introduction into North America is the Japanese plum, *P. salicina* Lindl., which was domesticated in Japan and was introduced into the United States about 1870.

The Raw Material of the Plum Breeder

Cultivated varieties of at least 12 species of plums are to be found in American orchards or growing in the wild, but most of the important commercial varieties are confined to 4 of these species. A wealth of types, varieties, and species is available for the fruit breeder.

The best known and most important of these groups are varieties of *Prunus domestica*, the European plums and prunes. Unfortunately they are not well adapted to regions with hot, dry summers or dry, cold winters. They are at home in the northeastern United States; in sheltered sections along the Great Lakes and in the Intermountain and Pacific Coast States they are at their best, as is evidenced by the extensive production of fresh fruit and dried prunes in this region. The European plums have been under domestication longest, and the

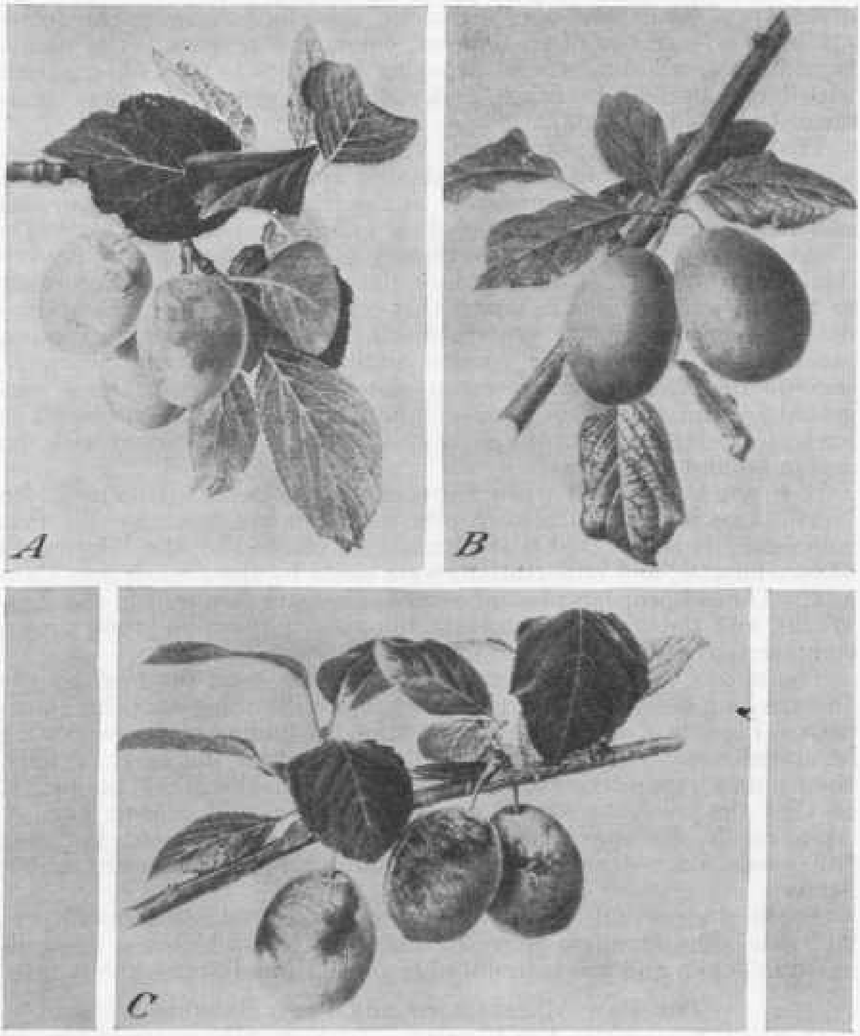

Figure 11.—Types of fruit in the group of *Prunus domestica*: *A*, Reine Claude, a high-quality plum of the Green Gage group; *B*, Bradshaw, formerly an important variety in the Lombard group of reddish plums used for canning and dessert, but being replaced by better varieties produced as a result of hybridization and breeding; *C*, Diamond, a blue plum of the Imperatrice group. The varieties of this group are of medium size, dark blue in color, with a heavy bloom.

fruits are notable for large size and attractive appearance. They vary in color from the green and golden yellow or the Reine Claude (Green Gage) and Yellow Egg groups to the red and dark purple of the

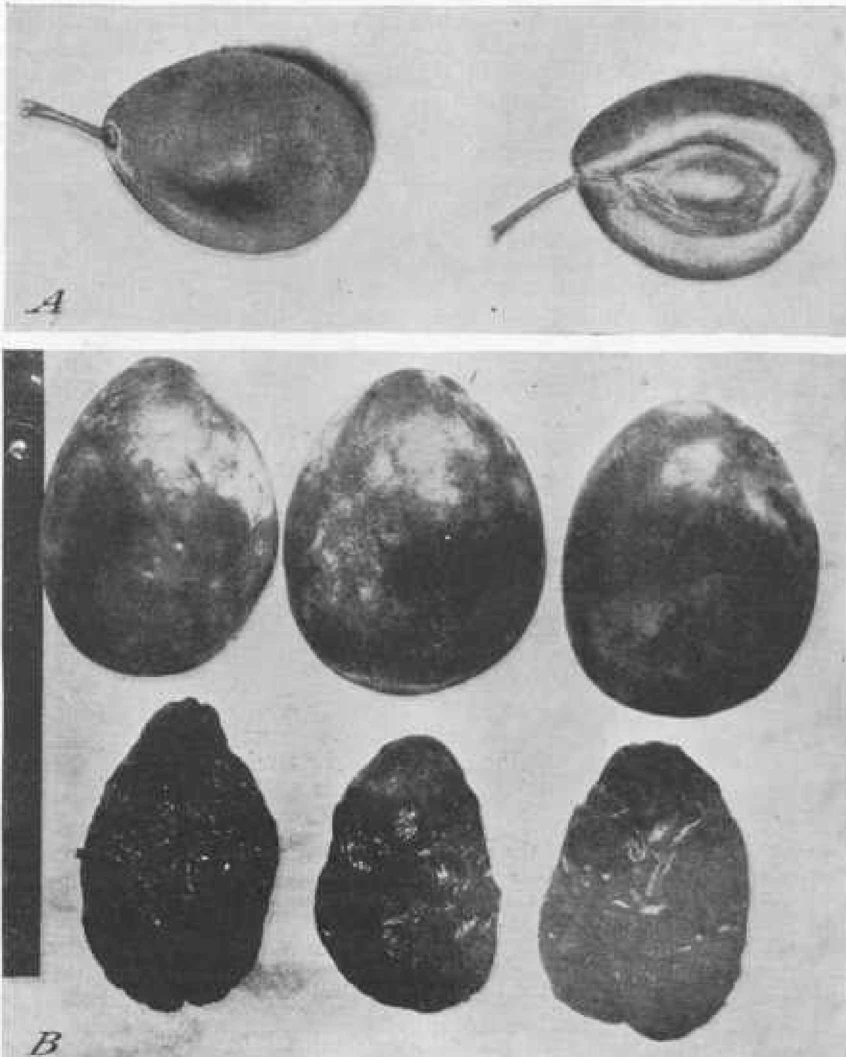

Figure 12.—Some of the most important varieties of *Prunus domestica* used for making prunes: *A*, Italian Prune, showing the shape of the fruits in the prune group; *B*, some varieties that produce large prunes when dried.

Lombard and Italian Prune (fig. 11). Italian Prune, Agen, Sugar, and Imperial Epineuse constitute an important group of European plums with firm flesh and high sugar content suitable for use fresh or as dried prunes (fig. 12). Other varieties, such as Tragedy, Reine

Claude, Bradshaw, and Golden Drop, are used principally for canning and dessert plums.

The damsons (*Prunus insititia*) of the Old World are quite different from the domesticas. The trees are more upright, compact, and dwarfish, the leaves and flowers are smaller, and the fruits are small, round, and quite tart, so that they are especially suitable for preserves and jams. Varieties of this group are hardy, vigorous, and productive, and the trees make good stocks for other species, being adapted to a wide range of conditions and thriving even when they are neglected. The Shropshire (fig. 13) and French are important

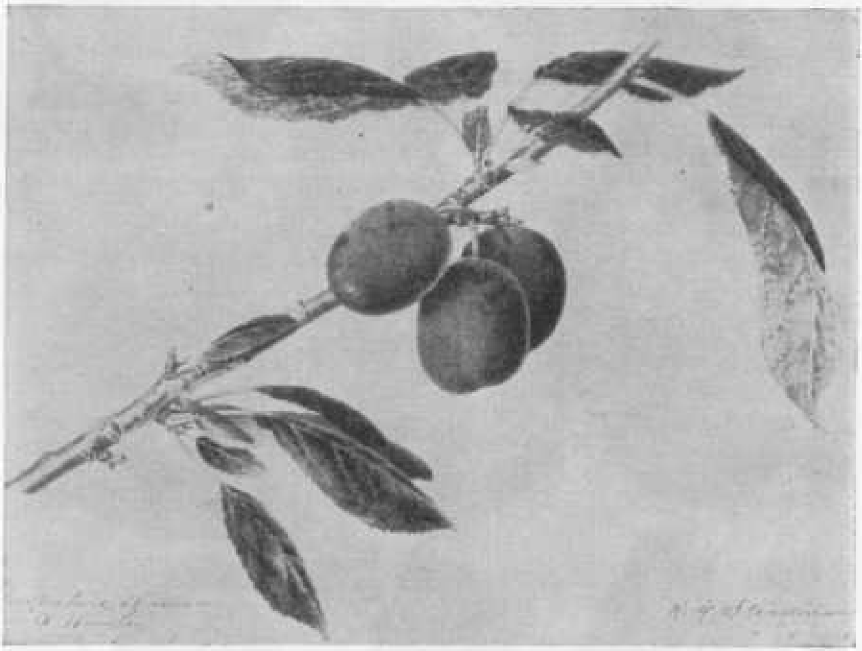

Figure 13.—**Shropshire, one of the most important varieties in the damson group of *Prunus insititia*. This small blue plum, like others belonging to this group, is used principally for preserves.**

blue damsons in this country, while the yellow Mirabelles are popular in France. The group as a whole has certain valuable qualities that appear to have been overlooked in breeding investigations.

The Japanese plums (*Prunus salicina*) are relatively new to North America, but in the short time since their introduction they have been widely planted and now rank second to the domesticas in commercial production. The trees are more spreading in habit than the domesticas or damsons, and in leaf and fruit characters they are very different, resembling the native American plums. The fruits are very attractive and are characterized by a yellow ground color overlaid by various shades of red. In some varieties the flesh color is a striking red, whereas fruit of the domesticas and damsons is green or yellow. Some recent hybrids of the salicina group (fig. 14) show distinct superiority

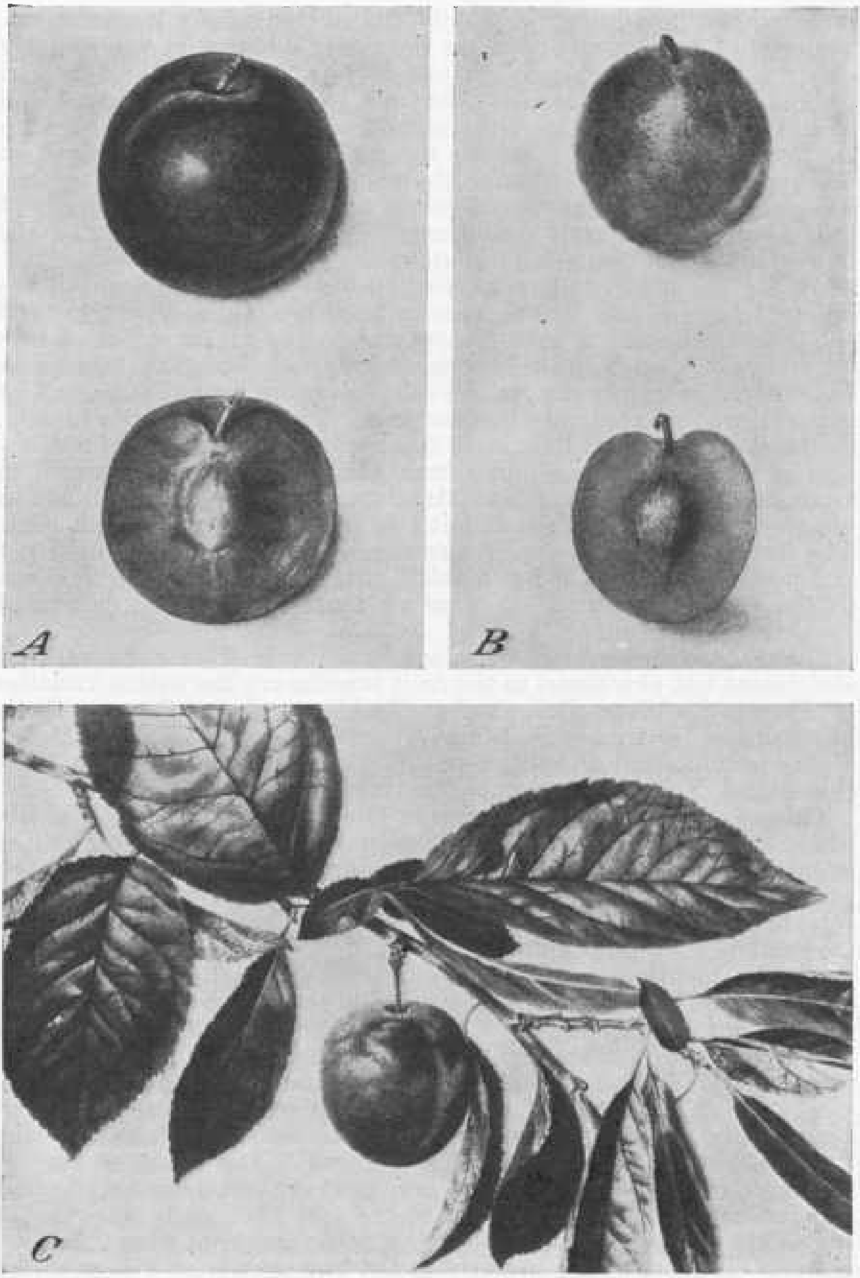

Figure 14.—Plum hybrids. *A*, *Prunus salicina* hybrid, variety Apple. This red-fleshed variety illustrates the round shape of the varieties of this species. *B*, America, a hybrid between *P. munsoniana* and *P. salicina*. *C*, Hybrid resulting from a cross of the purple-leaved plum *P. cerasifera* var. *pissardii* with *P. salicina* variety Abundance.

in flavor and in commercial possibilities over the early importations. Varieties of this group appear to be widely adapted in this country except in the very coldest climates. While the quality is not equal to that of the best domesticas, the fresh fruit is delicious in its blend of flavors. The varieties cross readily with one another and with the native americanas. Among the first Japanese plums grown in this country, Kelsey, Burbank, Abundance, and Satsuma are typical. The trees are hardy and productive, and they tolerate a variety of soils as well as climatic conditions. They blossom early, and the flowers are sometimes killed by late spring frosts.

Among the plums native to North America are varieties that are different in fruit and tree characters from the plums of Europe and the Orient. Botanists have divided the native American plums into a number of species and subspecies. Many of them have numerous characteristics in common, so that they overlap somewhat in present horticultural groups and classifications. *Prunus americana* Marsh., the most important of the native species, has a wide range of adaptation in this country, extending from Maine to Florida, westward to Utah, and northwestward into Manitoba. The tree is small, not as vigorous as the European, and it has rough, shaggy, grayish bark. The fruit is red, reddish yellow, or reddish orange, of pleasant flavor and good quality, but it has a thick, tough skin, and the flesh clings to the pit. De Soto and Weaver are among the typical cultivated varieties of americanas.

Other American species of minor importance from a commercial standpoint but of interest to the fruit breeder are the native varieties of *Prunus hortulana* Bailey; the Chickasaw plum, *P. angustifolia* Marsh.; and the wild-goose plums, *P. munsoniana* Wight and Hedr., of the southeastern and south-central United States, of which Wild Goose and Robinson are important varieties (*3*, *32*).

Other species of plums growing in North America are the Canada plum, *Prunus nigra* Ait., which is adapted to the north-central United States and Canada; the small beach plum, *P. maritima* Marsh., which grows along the eastern seacoast; and the western or Pacific plum, *P. subcordata* Benth., which grows east of the Coast Range in southern Oregon and northern California.

Finally, mention should be made of the myrobalan plum (*Prunus cerasifera* Ehrh.), a native of Europe, and the Simon or apricot plum, *P. simonii* Carr., a native of China. The myrobalan plum has been used a great deal in this country as a rootstock. Varieties of *P. cerasifera* and *P. simonii* are noted for their ornamental foliage.

This great collection of varieties and species affords an excellent opportunity not only for studying genetic relationships but for the development of new varieties by breeding. The study of the inheritance of characters in plums has, however, not been very extensive. This may be due in part to the fact that many varieties of plums are self-unfruitful; that is, they do not set fruit with their own pollen. This presents a problem to the fruit grower as well as to the plum breeder. It is, of course, impossible to obtain an inbred progeny to study the inheritance of characters if the blossoms cannot be selfed. Fortunately for both the breeder and the fruit grower, fruits can be obtained by cross-pollination, and not all varieties are self-unfruitful.

Objectives in Plum Breeding

It is a well-recognized fact that plum culture in North America has gradually been declining during the last 20 years. The reason for this is the failure to keep pace with the demand for fruits of high quality. Varieties that were satisfactory 25 to 50 years ago in most cases do not appeal to persons who have a taste for fruits of high quality. However, many varieties are still prized in the home garden even though they are not profitable to the large producers.

An important objective of any plum-breeding program should be the production of varieties of higher quality adapted to the various fruit regions of the country. None of the domestica plums of high quality can be grown satisfactorily south of Virginia or in the vast regions of the southwestern and south-central United States. Native American species grow in this part of the country, but their adaptability must be combined with the higher quality of other varieties and species. Work has been started in this direction, but it has met with failure because domestica and americana varieties have different chromosome numbers, and so far crosses between them have not yielded viable seedlings.

Further study is also needed in the direction of artificially increasing desirable mutations in plums. In a few instances desirable bud sports have been discovered, and careful search should be made to locate others.

In addition to high quality, consideration must be given to vigor, hardiness, and productiveness. Much has been accomplished in developing and selecting winter-hardy varieties for the Great Plains region. Similar work is needed to develop varieties adapted to regions with hot, dry summers.

Genetic and cytological studies are of first importance in initiating a plum-breeding program. Among the self-compatible varieties there is a wealth of valuable material that can be used as foundation breeding stock. Even before methods are developed for increasing fruitfulness in crosses between species, there is opportunity for research on the material within many of the plum species growing in this country.

Breeding Methods

The methods of breeding that have been described for the peach apply equally well to the plum. The breeder is confronted with the same problem of protecting the emasculated flowers in order to lessen damage to the pistils. With varieties known to be completely self-incompatible, emasculation is of course unnecessary, and time can be saved by omitting this operation.

The problem of seed germination and the production of new seedlings likewise confronts the plum breeder. The seeds from many crosses prove nonviable, and methods need to be worked out whereby a greater percentage of seeds can be made to grow.

Work of Private Breeders

The first work on plum improvement in this country consisted of attempts to obtain better strains of the native American plums by domesticating seedlings and selecting those most promising for size, flavor, and productiveness. The most extensive work in this direction seems to have been started by H. A. Terry, of Crescent, Iowa. From about 1860 until the time of his death in 1909 he had originated over 50 varieties from native species. While there is little information available as to the breeding methods or parents used, it is certain that he produced more new varieties than any private breeder since his time. Some of the more important varieties introduced by him are Gold, Hawkeye, Hammer, Downing, Crescent, and Terry.

Work on the breeding of plums was begun by C. G. Patten, a private breeder and a contemporary of Terry in the same State, at Charles City, Iowa, in 1867. He was impressed by the great number of native plums found growing in the wild, became interested in domesticating some of these, and selected the best for the prairie and upper Mississippi Valley regions. Hardiness or ability to withstand cold winters was a factor to be considered in the selection of varieties for that region. He worked with the American species. One of his best selections was tested by the Iowa Agricultural Experiment Station and was introduced as the Patten plum.

Beginning about 1870, J. W. Kerr, of Denton, Md., began the study and testing of a large number of varieties of plums. He likewise was interested in developing new varieties from native plums. Among the varieties introduced by him are Choptank, Sophie, and Maryland.

In California, Luther Burbank began his plum-breeding work about 1880, at Santa Rosa. He introduced and produced many desirable types. Among the important varieties he developed from seed imported from Japan are Burbank, Abundance, and Satsuma. He was particularly interested in the Japanese types and did much to popularize the varieties of this species in California, and to lay the foundations for their later testing and use as important commercial varieties in that State. He likewise made a number of crosses between *Prunus salicina* and other species, producing Climax, Bartlett, and Wickson from *P. salicina* × *simonii*, and America (fig. 14) and Golden from *P. munsoniana* × *salicina*. Other varieties introduced that have been grown commercially in California are Giant, Splendor, Standard, Santa Rosa, Formosa, and Gaviota.

Hedrick and associates (*19, p. 170–171*) make the following comment on Burbank's work:

One cannot briefly catalog the new forms of plants that have gone forth from his private place in California; they must number well into the hundreds; his biographer, in 1905, said that Mr. Burbank has worked with over two thousand five hundred distinct species (Harwood, W. S., New Creations in Plant Life I. 1905). Among these have been practically all of the species of plums now under cultivation, from which have been obtained, according to Mr. Burbank, hundreds of thousands of plum-seedlings of which the breeder has selected a score or more of very distinct sorts, all interesting and a few of them very valuable. The many other fruits, flowers and forage plants which Mr. Burbank has sent out, each involving the handling of countless seedlings, cannot be mentioned here. Nor can his methods and results be discussed, except to say that in them he is a unique figure in plant-breeding and that they have been such that he has exercised a powerful influence toward the improvement of plants. The practical results of Mr. Burbank's work have been as great or greater than those secured by any other person in plant-breeding, yet they have been magnified out of all bounds in the popular press and his work has been caricatured by calling the man a wizard and ascribing to him occult knowledge. Of the plants introduced by Mr. Burbank the proportion of really valuable commercial ones seems now to be small, but what he has done cannot be measured by money values; he has awakened universal interest in plant-breeding; has demonstrated that things unheard of before his time can be done with plants; and, all in all, his contributions in new forms of plants to horticulture and agriculture, in their intrinsic and educational value, make him the master worker of the times in improving plants.[6]

Millard W. Sharp, of Vacaville, Calif., in more recent years has produced and introduced several plum varieties. The method he used was to top-work many varieties into a single tree, allow free crossing, plant the seed, and make intensive selection of the resulting seedlings. Of the varieties he introduced, Sharky and Becky Smith have attained commercial importance.

Plum-breeding work has also been undertaken by Albert F. Etter and August Etter at Ettersburg, Calif. In recent years they have used as parents for hybrids Wild Goose, Marianna, Golden Drop, Agen (French prune), Japanese varieties, and Sierra, a peculiar domestica type that grows wild in Trinity County, Calif.; two wild native plums from Mongolia, and the native plums of Kansas. In all, this includes about a dozen species. The outstanding ability to produce new forms shown by the Sierra, the Kansas, and the Trinity plums is of particular interest. The Sierra hybrids exhibit wide variations in tree and fruit characters. These are under test at the present time, but no varieties have been introduced.

Harlan Rockhill, of Conrad, Iowa, has been engaged in fruit breeding since 1895. Among his recent selections are some promising plum hybrids from crosses of Waneta × Apex, Waneta × Moorpark, No. 10 × P. I. 78519, Waneta dwarf seedling × Apex × P. I. 78519. The last-mentioned cross is reported to be particularly hardy in wood and bud, having withstood temperatures of −26° to −36° F. during the winter of 1935–36. This variety and others are being tested further.

Plum Breeding at State and Federal Stations

South Dakota

Work was undertaken at the South Dakota Agricultural Experiment Station in 1895 by Hansen (*15*) in an attempt to select American varieties of plum that would be satisfactory for the Great Plains region. Up to 1937 fully 10,000 native plum seedlings of *Prunus americana* had been grown in an endeavor to find native seedlings better in size and quality than those already grown. Wastesa, Yuteca, Zekanta, Huya, and Topa were selected and named. Yuteca is large; Wastesa is outstanding for size and quality. Hansen attempted to introduce quality into the native plums by crossing these into a number of other species such as peach, cherry, and apricot, as well as with other varieties of plum. The following is a list of crosses made, together with notes on the progeny:

Prunus besseyi Bailey (Bessey cherry or western sand cherry) × apricot plum *P. simonii* Carr. Not hardy, fruits sparingly. One variety only named but the trees have since been discarded.

P. besseyi × Japanese plum (*P. salicina* Lindl.). Progeny highly fertile, hardy. widely cultivated. Among varieties named are Opata, Sapa, and Oka.

P. besseyi × native plum (*P. americana* Marsh.). Two varieties named, Sansoto and Cheresoto, which are highly fertile.

[6] Burbank's achievements and limitations have also been summed up critically by Jones (*22*).

P. besseyi × Apricot (*P. armeniaca* L.). Progeny very shy bearers.

P. besseyi × peach (*P. persica*). Flowers of hybrid (Kamdesa) were sterile.

P. americana × *simonii*. Three varieties named, Toka, Hanska, and Kaga, which are strong pollinators for other varieties. The fruit is fragrant, flesh firm, and of excellent quality.

P. simonii × *americana*. This cross produced Tokata: the fruit is large and of excellent flavor. The seedlings of this cross require cross-pollination.

P. salicina × *americana*. The progeny of this cross is highly fertile. Five varieties have been introduced and widely cultivated—Waneta, Kahinta, Tawena, Oziya, Tecumseh.

P. americana × *salicina*, the reciprocal of the former species cross, has yielded many choice hybrids which are self-fertile and interfertile.

Canada plum (*P. nigra* Ait.) × *P. salicina*. This combination has yielded the varieties Cree and Pembina.

P. salicina × *nigra* has given the variety Ojibwa.

From Canada plum, *Prunus nigra*, pure selections have been made and introduced as Assiniboin and Winnipeg.

Since 1895 selections have been made from over a million seedlings of *Prunus besseyi*. The thirteenth generation has now fruited.

New York

At the New York (State) Agricultural Experiment Station, Geneva, plum breeding was started as early as 1893, when a few open-pollinated seedlings were grown. Under test the seedlings proved to be of no commercial value. From 1908, when the first crosses were made at the New York station, up to the present time, 78 varieties, 6 seedlings, and 7 United States Department of Agriculture introductions have been used in breeding work, and 546 crosses, 16 selfs, and 26 open pollinations have been made. Only 519 seedlings have been planted in the orchard. The set of seed has not been high, and there were serious losses between the time of harvesting the seed and planting. Considerable difficulty has sometimes been experienced in getting the seeds to grow. A few Japanese plums (*Prunus salicina*) have given seedlings, but no seedlings have been obtained from the early-maturing European or domestica group.

It has been the experience in the plum-breeding work at Geneva that it is difficult to obtain large quantities of seed from hand-pollinated trees. The flowering season is usually brief and there is often a high mortality of blossoms. It has been suggested that the use of tents and bees for pollination would be the economical method for securing large numbers. The comparatively few seedlings that have fruited indicate that it is not difficult to make rapid progress in plum improvement. The large-fruited, attractive, poor-quality Grand Duke has given promising new varieties when crossed with high-quality Golden Drop and Agen. Imperial Epineuse and Pearl have also imparted good quality to a high degree in crosses. The varieties that have been used most extensively and the number of times they have been used are: Abundance 23, Agen 23, Albion 8, Archduke 8, Beauty 17, Burbank 57, Clyman 11, Formosa 13, Golden Drop 8, Grand Duke 23, Hall 12, Imperial Epineuse 30, Jefferson 8, Miller Superb 10, Oullins 22, Reine Claude 19, Rivers Early 12, Santa Rosa 16, Shiro 10, Stanley 16, Tragedy 8, and Yellow Egg 28. A list of plum varieties introduced by the New York station is given in table 4.

TABLE 4.—*Plum varieties introduced by the New York (State) Agricultural Experiment Station*

Variety introduced	Parentage	When crossed	Year intro-duced	Purpose
Albion	Golden Drop × Grand Duke	1908	1929	Very late season.
American Mirabelle	Imperial Epineuse × Mirabelle.	1911	1925	Home and roadside market.
Hall	Golden Drop × Grand Duke	1908	1925	Do.
Stanley	Agen × Grand Duke	1913	1926	Commercial market.

The opinion is expressed by Richard Wellington that by intercrossing hybrids such as Hall, Albion, and Stanley, and by crossing them on high-quality plums such as Imperial Epineuse, varieties of better quality should be obtained. A large number of varieties and species of plums are grown on the grounds of the New York station as basic material for the production of better varieties.

California

The California Agricultural Experiment Station at Davis has grown a large number of varieties of plums on the station grounds. These have been used in studies on pollination and variety behavior under California conditions. Because of the demand for improved varieties of plums, breeding work was started in 1934. Poor germination of plum seeds has been an important factor in slowing down the production of seedlings. All the species of plums grown in North America, together with some miscellaneous species, are being utilized. A complete list is given in the appendix. Genetic and cytological work on interspecific crosses is under way.

Iowa

At the Iowa Agricultural Experiment Station a large number of plum crosses have been made, using *Prunus americana*, *P. salicina*, *P. domestica*, and *P. maritima;* also *P. armeniaca*. Interspecific hybrids between *P. americana* and *P. salicina* are grown, and 180 trees resulting from crosses between species and varieties are now being grown in the nursery at Ames. These crosses were made during the period 1931–33. Varieties used as pollen parents and the number of times they were used are: Elliot 5, Hennepin 4, Japex 2, Monitor 2, Sapa 5, Waneta 6, and Anthony, Zumbra, Red Wing, and Burbank each 1. Crosses between the plum and the Russian and Moorpark apricots have been made. Greenhouse trees are being utilized in the breeding work with *Prunus*, and many hundreds of nonfruiting crosses not listed above have been made on them. The interspecific hybrids that prove to be fertile will be preserved for future crossing. The trees are brought into the greenhouse about January 10 and are ready for crossing about 3 or 4 weeks later.

Minnesota

Plum-breeding work at the Minnesota Agricultural Experiment Station was begun in 1889 at University Farm by S. B. Green, horticulturist. In the same year breeding work was also started by E. H. S.

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Dartt at Owatonna Tree Station, a branch station of the University. This work consisted of selection of open-pollinated seed from superior native varieties. More extensive and systematic work began in 1907 with the establishment of the present University of Minnesota Fruit Breeding Farm. Up to the present 20 varieties have been introduced—Anoka, Elliot, Ember, Golden Rod, Hennepin, La Crescent, Mendota, Monitor, Mound, Newport, Nicollet, Radisson, Red Wing, St. Anthony, Superior, Tonka, Underwood, Waconia, Winona, and Zumbra. They are of special interest for the upper Mississippi River Valley area because of their winter hardiness, but are worthy of testing in other sections also, and they should provide material for additional studies. Detailed descriptions of these varieties, their parentage, and the dates of introduction are given in the appendix, which also includes a list of the varieties now being used in further breeding studies.

A considerable amount of breeding material is available involving various species of native and foreign plums and other closely related species of stone fruits. Since winter hardiness is a primary requisite, all breeding material is subjected to severe field tests to determine its resistance to cold.

Federal Field Stations

A number of varieties and specific crosses of plum have been made in cooperative investigations by the Bureau of Plant Industry, United States Department of Agriculture, and Leland Stanford Junior University at Palo Alto, Calif. The following varieties and species have been used as seed parents: Agen, Anita × Sugar, Becky Smith, Burbank, Clyman, Duarte, Fremonti, Giant, Golden Drop, Imperial Epineuse, Improved French, Methley, Pond, Sergeant, Tragedy, Wickson, and *Prunus bokhariensis* Royle. In addition the following varieties have been used as pollen parents: Sugar, Gaviota, Formosa, Santa Rosa, Beauty, Satsuma, Standard, and Tunis. Two promising hybrids, Methley × Wickson and Wickson × Santa Rosa, have been selected. The latter variety is a delicious plum, representing a particularly fine blend of flavors and ripening just after Santa Rosa. The tree is productive and in preliminary tests seems to be well adapted to California conditions. A complete list of plum hybrids produced is given in the appendix to this section.

At the Northern Great Plains Field Station, Mandan, N. Dak., more breeding work has been done with plums than with any other fruit except apples. Thousands of seedlings have been grown from the native wild plum and cultivated varieties. A great deal of variation is to be found within the *Prunus americana* species, and over 50 selections were made, some of which were propagated for a more thorough test. A few of these are ready for more extensive testing in the northern Great Plains area. Of late years a large number of Japanese hybrid seedlings have been grown. Hybridizing work has been in progress, using hardy *P. americana* and *P. nigra* varieties, these being crossed with Japanese varieties, domestica varieties, *P. simonii*, *P. tomentosa* Thunb., apricots, and cherries, and with such hybrid plum varieties as Waneta, Underwood, and Sapa. Some of the progenies are now bearing fruit, and a few selections have been made.

Plum Breeding in Canada

Plum breeding at the Horticultural Experiment Station, Vineland, Canada, was started in 1913. From 1913 to 1935, 4,240 seedlings were grown. Seeds were planted from 57 open pollinations and 35 crosses. Out of this number 16 had horticultural value. During the period 1931 to 1933, 860 seedlings were grown from crosses in which Imperial Epineuse was used as the female parent, and Grand Duke, Coe Fellenberg, and President have been used as pollen parents. The object of the cross was to produce a high-quality blue plum for the export trade.

Genetic and Cytological Studies of the Plum [7]

Experiments with plums were begun at the John Innes Horticultural Institution in England by W. J. Backhouse and Crane (*8*) in 1911, to investigate the genetic composition of plum trees by raising selfed offspring. The characters studied were (1) hairiness of shoots, leaf petioles, and fruits; (2) smoothness of bark and size and shape of leaves; (3) habit of growth of tree; and (4) bark and fruit color.

All the varieties of plums studied with hairy wood surface proved to be heterozygous for that character. Serrate leaf character proved to be homozygous in the Pershore variety, and crenate leaf margin homozygous in the Czar family. The irregular margin appeared to be heterozygous in varieties possessing this character.

Flesh color varied. Varieties in which yellow was the predominating flesh color have, when selfed, given seedlings with a green, and a wholly yellow flesh.

As to fruit size and shape, many of the differences were recognized as doubtless quantitative. The oblate fruit of Early Transparent, for example, and the pyriform fruit of the Pershore variety proved to be homozygous for these forms. With some selfed families, length and shape varied in the progeny.

Wellington (*32*) has carried on extensive investigations at the New York (State) Agricultural Experiment Station in breeding and genetic studies with a number of plum varieties and species. He found the oval fruit shape of *Prunus domestica* dominant to oblate. Thick bloom on the surface of the fruit is dominant to thin bloom. Yellow color is recessive to red, purple, and black. The freestone character is recessive to clingstone. Many varieties are heterozygous for the freestone character, freestones being obtained from the cling and semicling parents.

Some varieties of our domestica plums set fruit with their own pollen; others are partially self-incompatible, while a third group fail entirely with their own pollen. Insititia varieties grown in this country are self-fruitful. Nearly all of the varieties of the Japanese group are self-sterile.

Tufts has found the following important varieties of domestica plums to be self-unfruitful in California: Clyman, Tragedy, Imperial Epineuse, President, Standard, Sergeant, Washington, Jefferson, Quackenboss, Diamond, and Silver. Self-fruitful varieties were

[7] This section is written primarily for students and others professionally interested in genetics or breeding.

Agen, Giant, Pond (partially), Grand Duke (partially), California Blue, Yellow Egg, and Sugar.

The following Japanese and hybrid plums were self-unfruitful in California: Abundance, Burbank, Duarte, El Dorado, Formosa, Gaviota, Kelsey, Prize, Satsuma, Sultan, Upright, and Wickson. Methley, Climax, Beauty, and Santa Rosa are partially self-fertile. Formosa and Gaviota were also found to be interunfruitful. The Tragedy plum will fertilize several Japanese varieties but is not fertilized by them.

Crane and Lawrence (*10*) observed that certain of the domestica plums were completely self-and cross-incompatible, while others, such as President and Late Orange, were reciprocally incompatible but set fruit when pollinated with Green Gage (probably Reine Claude). Early Rivers, when pollinated by Blue Rock, set a full crop, while in the reciprocal cross only a few fruits set. Varieties such as Golden Drop, Coe Violet, and Jefferson, were found to be completely self- and cross-incompatible (*9*).

Incompatibility Due to Genetic Make-up

Experiments by a number of investigators, East (*13*), Lehmann (*24*), and others, have shown that sterility is determined by genes just as are morphological characters. East designated these genes S, and they form a multiple allelomorphic series, S_1, S_2, S_3, etc. As in the case of other allelomorphs, any two may be carried by a given plant. While this concept is based on the results of studies with *Nicotiana*, it fits into the observations made on stone fruits and explains incompatibility in plums and cherries. The essential features of the genetic behavior of incompatibility is that pollen cannot function in the style of a plant carrying the same incompatibility factors as the pollen. Self-pollinations or cross-pollinations among individuals carrying the same sterility genes fail because either the pollen tubes grow so slowly that in normal cases they are unable to reach the ovules in time to effect fertilization, or the growth of the pollen tube is inhibited in the stylar tissue. Consequently, groups of individuals occur within which all cross- and self-pollination fails to effect fertilization. Thus, individuals of the constitution S_1, S_2, cannot be fertilized by S_1 or S_2 pollen. If, however, such individuals are crossed by S_3 S_4, both the S_3 and S_4 pollen can penetrate the style of the mother and effect fertilization. It will be seen that the offspring from such a cross, allowing all combinations possible, will constitute four intrasterile, interfertile groups of the composition $S_1 S_3$, $S_1 S_4$, $S_2 S_3$, $S_2 S_4$.

With certain of our plum varieties, of either the Japanese or the domestica species, self-unfruitfulness occurs when those varieties carry a gene for incompatibility. Likewise, varieties would be cross-unfruitful if both parents carried the same genes for incompatibility.

Chromosome Numbers in the Plums

In the genus *Prunus* the basic chromosome number is 8. All the varieties examined among the myrobalan plums (*P. cerasifera*), American plums (*P. americana*), and Japanese plums (*P. salicina*) show the diploid number ($2n$) to be 16. Other species, notably the sloe (*P. spinosa* L.), have the tetraploid number or 32 chromosomes, and a still greater number (48) is found in the important groups of European plums (*P. domestica*) and the damsons (*P. insititia*).

Hybrids of *Prunus domestica* (48) × *P. cerasifera* (16), and *P. insititia* (48) × *P. spinosa* (32) have the intermediate chromosome numbers, 32 and 40, respectively.

According to Crane and Lawrence (*10*), the hybrids that they have obtained between *Prunus domestica* and *P. insititia*, both hexaploid, have always been completely interfertile; but from crosses between diploid and polyploid, and different polyploid forms, such as *P. domestica* × *P. cerasifera* and *P. insititia* × *P. spinosa*, fruits with viable seeds are rarely produced. Crosses between damsons and other varieties of *P. insititia* and *P. domestica* when attempted have always set fruit and developed good seeds freely. Wellington has also made many interspecific crosses. Crosses have been made successfully between *P. domestica* and *P. insititia*. With a large number of other interspecific crosses, however, involving *P. domestica* × *P. armeniaca* and its reciprocal; *P. domestica* × *P. tomentosa*, and *P. domestica* × *P. americana*, few fruits were obtained or the seeds failed to grow. Insofar as is known, triploid varieties of *Prunus* are found only as ornamentals, their degree of sterility being too high to enable them to be grown for their fruits.

Appendix (Plum)

Table 5.—*Locations of plum-breeding work and names of workers in United States and other countries*

State or country, institution, and location	Early workers	Workers actively engaged at present
California:		
Agricultural Experiment Station, Davis.	E. J. Wickson, W. L. Howard, A. H. Hendrickson.	W. P. Tufts, E. C. Hughes.
U. S. Department of Agriculture, Davis.		J. R. King.
U. S. Department of Agriculture, Palo Alto.		W. F. Wight.
Iowa:		
Agricultural Experiment Station, Ames.	S. A. Beach	T. J. Maney.
Minnesota:		
Agricultural Experiment Station, University Farm, St. Paul.	Charles Haralson, M. J. Dorsey, W. S. Valleau, J. H. Beaumont.	W. H. Alderman, A. N. Wilcox.
New York:		
Agricultural Experiment Station, Geneva.	U. P. Hedrick, W. H. Alderman, M. J. Dorsey.	R. Wellington, Olaf Einset.
North Dakota:		
U. S. Department of Agriculture, Northern Great Plains Field Station, Mandan.	Max Pfaender	William P. Baird.
South Dakota:		
Agricultural Experiment Station, Brookings.	N. E. Hansen	N. E. Hansen.
Canada:		
Horticultural Experiment Station, Vineland, Ontario.		F. E. Palmer, G. H. Dickson.
England:		
John Innes Horticultural Institution, Merton.		W. J. C. Lawrence.
Australia:		
Department of Agriculture, Sydney, New South Wales.		H. Wenholz.

TABLE 6.—*Varieties used in plum breeding at the University of Minnesota*

Parentage	Period during which crosses were made	Total seedlings grown	Seedlings of horticultural value	Apparent value of parents used
		Number	*Number*	
Assiniboin Open	1915	208	16	Fair.
Assiniboin × Surprise	1925–27	229		
Reciprocal cross	1926	181		Poor.
Burbank × Assiniboin	1920–26	26		
Reciprocal cross	1925–26	6		
Burbank × De Soto	1913	43	3	
Reciprocal cross	1912	27	1	Fair.
Burbank × Kaga	1920–25	233	33	Good.
Reciprocal cross	1920–26	15		
Burbank × Older	1927	10		
Reciprocal cross	1923–27	14		
Burbank Open	1923–26	39	3	Fair.
Burbank × *Prunus americana*	1913–26	279	28	Good.
Reciprocal cross	1922–27	70	1	
Burbank × Red Wing	1920	19	1	Fair.
Reciprocal cross	1920	2	1	
Burbank × sand cherry	1920	72	2	Fair.
Reciprocal cross	1921	10		
Burbank (sand cherry × Climax)	1920	30		
Reciprocal cross	1921	48	2	Fair.
Burbank × S. Dak. No. 27	1921–26	9		
Reciprocal cross	1924–26	89	1	
Burbank × Surprise	1924–26	13		
Reciprocal cross	1921–26	10		
Burbank × Wakapa	1921	1		
Reciprocal cross	1912–21	20	2	
Burbank × Wolf	1912–26	77	6	Good.
Reciprocal cross	1923–27	28		
(Burbank × Wolf) open	1912	31		
Compass × Burbank	1912	60	2	Fair.
Compass × Climax	1912	107	5	Do.
Compass × Formosa	1912	37	1	Do.
Early Red × *P. americana*	1912	21		
Elliot × Mendota	1922–27	25		
Emerald × Assiniboin	1920	179		Poor.
Emerald × Tonka	1920–21	30		
Emerald × (Wyant × Gold)	1924	5		
Reciprocal cross	1924	15		
Omaha × Burbank	1912	39	4	Good.
Omaha × Santa Rosa	1912	23	2	
Omaha × Winnipeg	1912	20		
(Pin cherry × sweet cherry) × sand cherry or sand cherry hybrid	1912	81	11	Good.
Red Wing × Assiniboin	1920–21	156		
Red Wing × Kaga	1920–23	54	2	Fair.
Reciprocal cross	1920	3		
Sand cherry × Climax	1912	60	5	Good.
(Sand cherry × Climax) × Sapa	1920	21	1	
(Sand cherry × Climax) × Tonka	1920–21	25		
Reciprocal cross	1920		3	
Sand cherry × Formosa	1912	27	4	Good.
Sapa × Surprise	1924	24		
Satsuma × Compass	1912	26		
Reciprocal cross	1912	29	1	
Shiro × *P. americana*	1912	21	4	Good.
Shiro × S. Dak. No. 33	1913	31	7	Do.
Reciprocal cross	1912	1		
Shiro × Winnipeg	1912	38	7	Do.
Reciprocal cross	1912	1	1	
S. Dak. No. 27 × Monarch	1924–26	50		
S. Dak. No. 27 × October Purple	1924	23		
Reciprocal cross	1924	1		
S. Dak. No. 27 × Santa Rosa	1925–26	91	7	Good.
Stella, open	1912–15	72	1	
Tonka × Assiniboin	1920–25	209		Poor.
Tonka × Red Wing	1920	33		
Reciprocal cross	1920	3		
Wakapa × First	1912	45		
Wakapa × *P. cerasifera pissardii*	1912	28		
Wakapa × Wickson	1921	26		
Reciprocal cross	1921	3		
Wakapa × Wyant	1912	22		
Winnipeg, open	1915	93	4	Fair.

TABLE 6.—*Varieties used in plum breeding at the University of Minnesota*—Continued

Parentage	Period during which crosses were made	Total seedlings grown	Seedlings of horticultural value	Apparent value of parents used
		Number	*Number*	
Zekanta × *P. americana*	1912	20	2	
Minn. No. 2 (Burbank × Wolf) × Burbank	1924	18		
Reciprocal cross	1924	18		
Minn. No. 6 (Burbank × Wolf) × Terry	1923	21		
Minn. No. 16 (Abundance × Wolf), open	1912	30		
Minn. No. 35 (Abundance × Wolf) × Burbank	1920	10		
Reciprocal cross	1920	97	5	Fair.
Minn. No. 55 (Abundance × Wolf) × No. 57 (Shiro × Winnipeg)	1924–26	64		Poor.
Reciprocal cross	1924–26	65		Do.
Minn. No. 55 (Abundance × Wolf) × No. 63 (Shiro × Winnipeg).	1924–26	46		
Minn. No. 55 (Abundance × Wolf) × No. 90 (Burbank × Wolf) 21.	1924	87	2	
Minn. No. 55 (Abundance × Wolf) × No. 104 (Burbank × ?)	1924	25		
Minn. No. 59 (Shiro × Winnipeg) × No. 57 (Shiro × Winnipeg)	1924–27	64		
Reciprocal cross	1925–26	4		
Minn. No. 62 (Shiro × Burbank) × No. 57 (Shiro × Winnipeg)	1924–25	63		
Minn. No. 66 (Shiro × Wolf) × No. 65 (Shiro × Wolf)	1924–25	25		
Reciprocal cross	1925	1		
Minn. No. 76 (Burbank × *P. americana*) × No. 62 (Shiro × Burbank).	1925–26	23		
Minn. No. 84 (S. Dak. No. 33 × Shiro) × No. 77 (Shiro × native).	1924–26	43		
Minn. No. 90 (Tonka open) × No. 55 (Abundance × Wolf)	1924	111		Poor.
Minn. No. 92 (Omaha × Wyant) × No. 74 (Santa Rosa × Bursota × Winnipeg).	1924	95		Do.
Reciprocal cross		2		
Minn. No. 92 (Omaha × Wyant) × No. 106 (Omaha × Santa Rosa).	1924–25	64		
Reciprocal cross	1925	6		
Minn. No. 98 (?) × Winona, reciprocal cross	1923	24	2	
Minn. No. 98 (?) × No. 96 (Zekanta × apricot)	1925	20		
Minn. No. 106 (Omaha × Wyant) × No. 55 (Abundance × Wolf).	1926	36		

TABLE 7.—*Plum introductions of the Minnesota Agricultural Experiment Station*

Variety	Parentage	When crossed or seed collected	When introduced	Descriptive notes (special value and superior characters)	Estimated acreage now planted
Anoka (Minn. No. 118)	Burbank × De Soto	1913	1922	Hardy; productive	Small.
Elliot (Minn. No. 8)	Probably apple plum × *Prunus americana*.	1907	1920	Very hardy; productive; good quality; late season.	175 acres.
Ember (Minn. No. 83)	Shiro × S. Dak. No. 33.	1913	1936	High quality; late season; long-keeping quality; exceptional adherence to tree.	Small
Golden Rod (Minn. No. 120).	Shiro × Howard Yellow.	1913	1923	Vigorous tree; larger firm yellow fruit. (Variety a shy bearer.)	50 acres.
Hennepin (Minn. No. 132).	Satsuma × *P. americana*.	1911	1923	Hardy; productive; red flesh	Small.
La Crescent (Minn. No. 109).	Shiro × Howard Yellow.	1913	1923	Very high quality; large, vigorous tree.	100 acres.
Mendota (Minn. No. 5).	Burbank × Wolf	1908	1924	Very large fruit; good quality	Small.
Monitor (Minn. No. 70).	Probably Burbank × *P. americana*.	1912	1920	Large, high-quality fruit; hardy; regularly productive.	300 acres.
Mound (Minn. No. 50).	Burbank × Wolf	1908	1922	Large size of fruit; productive.	([1]).
Newport (Minn. No. 116).	Omaha × Pissardii	1913	1923	An ornamental with purple foliage.	25 acres.
Nicollet	(*P. avium* × *pensylvanica*).[2]	1912	1925	Dwarf, bushlike; fruit similar.	50 acres.

[1] All in scattered landscape plantings.
[2] Open pollen parent is *Prunus besseyi* or a hybrid of this species.

TABLE 7.—*Plum introductions of the Minnesota Agricultural Experiment Station*—Con.

Variety	Parentage	When crossed or seed collected	When introduced	Descriptive notes (special value and superior characters)	Estimated acreage now planted
Radisson (Minn. No. 157).	*P. salicina* × *americana*.	1908	1925	Early-maturing high-quality fruit; adapted to northern locations.	Small.
Red Wing (Minn. No. 12).	Burbank × Wolf	1908	1920	Large high-quality fruit; exceptional freestone.	250 acres.
St. Anthony (Minn. No. 145).	*P. besseyi* (or hybrid) × Satsuma.	1912	1923	Very hardy and productive; red flesh.	50 acres.
Superior (Minn. No. 194).	Burbank × Kaga	1920	1932	Very productive and early bearing; fruit very large, firm, excellent quality.	100 acres.
Tonka (Minn. No. 21).	Burbank × Wolf	1908	1920	Very productive; firm flesh; high quality.	300 acres.
Underwood (Minn. No. 91).	Shiro × Wyant	1911	1920	Very vigorous; hardy; productive; early ripening; excellent quality.	500 acres.
Waconia (Minn. No. 10).	Burbank × Wolf	1908	1923	Hardy; productive; quality only fair.	Small.
Winona (Minn. No. 80).	*P. salicina* × *americana*.	1909	1922	Hardy; productive; high quality; late season.	Do.
Zumbra	(*P. avium* × *pensylvanica*).[2]	1912	1920	Dwarf, bushlike; very productive; excellent culinary quality.	100 acres.

[2] Open pollen parent is *Prunus besseyi* or a hybrid of this species.

Plum Hybrids Produced and Under Test in Breeding Investigations of United States Department of Agriculture and Leland Stanford Junior University at Palo Alto, Calif.

Year	*Parents*
1921	Agen × Anita.
1931	(Agen × Anita 18–31) × Imperial Epineuse.
1929	Agen × (Coe × Sugar).
1922	Agen × Standard.
1920	Agen × Sugar.
1931	(Agen × Sugar 18–12) × Imperial Epineuse.
1920	Anita × Sugar.
1931–32	(Anita × Sugar) × Agen.
1934	Becky Smith × Tunis.
1920	*Prunus bokhariensis* × Methley.
1921	*P. bokhariensis* × Sugar.
1920	*P. bokhariensis* × Wickson.
1934	Burbank × Formosa.
1932	Burbank × (*P. fremonti* × *cerasifera pissardii* 11–3 [8]).
1933	Burbank 2010 × Gaviota.
1932	Burbank × Satsuma.
1932	Clyman 12010 × (Anita × Sugar 18–45).
1934	Duarte × Santa Roas.
1933	(*P. fremonti* × *cerasifera pissardii* 11–31) × *P. bokhariensis* × Methley 6–6).
1924–26	Giant × Imperial Epineuse.
1919	Golden Drop (Coe) × Sugar.
1931	(Golden Drop (Coe) × Sugar) × Imperial Epineuse.
1926	Imperial Epineuse × Improved French.
1924–26	Imperial Epineuse × Tragedy or Agen.
1926	Improved French × Tragedy.
1920	Methley × Wickson.
1935	(Methley × Wickson 11–56) × Beauty.
1932–33	(Methley × Wickson 11–54) × Satsuma.

[8] The hyphenated numbers following certain varietal names refer to row and tree locations.

1933	(Methley × Wickson 11–57) × (Wickson × Santa Rosa 15–23).
1921	Pond × Agen.
1926	Sergeant × Improved French.
1926	Tragedy × Clyman.
1921	Wickson × *P. bokhariensis*.
1933	Wickson 7–24 × (*P. bokhariensis* × Methley 6–6).
1921	Wickson × Santa Rosa.
1935	Wickson × (Wickson × *P. bokhariensis*15–21).

Plum Material at the California Agricultural Experiment Station, Davis, Calif.[9]

Prunus domestica:
Admiral
Agen (French)
Altharm
Anita
Archduke
Arctic
Austrian Prune
Autumn Compote
Bavay
Bird Prune
Bittern
Black French
Black Prince
Blue Rock
Boddaert
Bradshaw
Bridge
Bulgarian
Burton Prune
California Blue
California Red
Callas
Champion (Burton)
Champion (Villa)
Clairac Mammoth
Clyman
Coates 1401
Coates 1403
Coates 1414
Coates 1418
Columbia
Communis
Crimson Drop
Curlew
Czar
De Caisne
De Montfort
Denbigh
Diamond
Diana
Dosch
Double × French
Duane
Duchess
Dulce
Dunlap

Prunus domestica—Con.
Earliana
Early Favorite
Early Golden Drop
Early Royal
Early Tragedy
Emilie
Empire
Femonzi
Field
Florence
Fraulein
German Prune
Giant
Gill
Golden Drop
Golden Prune
Golden Transparent
Goliath
Grand Duke
Green Gage
Gueii
Hall
Hand
Hector
Heron
Honori
Hulings
Hungarian
Ickworth
Imperial
Imperial Gage
Italian Prune
Jefferson
Junction City Prune
June Fourth
Kaiser
Kimball
Kirke
Large English
Late Orange
Late Orleans
Late Tragedy
Leighton Italian
Liberty Prune
Lincoln

Prunus domestica—Con.
Lombard
Long Green
Long Stem
Los Angeles
Lucombe
Mallard
Margaret
McLaughlin
Middleburg
Miller Superb
Missouri Green Gage
Monarch
Monk
Mount Royal
Moyer
Napa
Newark
New Oregon Prune
Oullins
Pacific
Palatine
Papagone Prune (P. I. 40498)
Peach
Pearl
Peters
Pond
President
Primate
Prinlow
Purple Gage
Quackenboss
Rayburn
Reuter Early Italian
St. George
St. Jean
St. Martin
Sannois
Sergeant
Sharpe Imperial
Shipper
Silver Prune
Smith Orleans
Smith Late
Splendor

[9] This list of variety names is approximately as submitted by the California station. The names are those under which the material is recorded, and not all of them are necessarily intended as authentic variety names. The list apparently contains a considerable number of names representing local strains and other names that do not conform to the generally accepted code of nomenclature. It is impracticable to attempt to bring the nomenclature in all cases into harmony with the code, therefore only a few changes representing obvious differences have been made.

Prunus domestica—Con.
Standard
Stanley
Stark Green Gage
Steward Prune
Stint
Stuart
Sugar
Super Prune
Swan
Sweetest
Tardeva de Moleta
Tatge
Tennant
Tragedy
True Blue
Tulare
Turkish Prune (synonym of Italian Prune)
$2000 Prune
Uncle Ben
Ungarish
Victoria
Voronesh
Wales
Washington
Wilhelmina
Williamson Tragedy
Yakima
Yellow Egg
Yellow Gage
Yellow Imperial
York State Prune
Zucheriva del Vesuvia

Prunus salicina:
Abundance
Alpha
Amador
Apex
Beauty
Becky Smith
Best's Hybrid
Blood Plum
Blue Gown
Botan
Burbank
Burton
Chabot
Clarice
Collie
Del Norte
Earliest of All
Engre
Extra Early Satsuma
Florida
Georgeson
Hale
IXL
Kelsey
McRea
Miss Edith

Prunus salicina—Con.
Occident
October
Ogon
Pasha
Purple Flesh
Raisin
Red June
Sachem
Santa Rosa
San Francisco
Satsuma
Schattenburg
Sherkey
Strang
Tribble Early Beauty
Ulatis
Valleda
Willard
Wilson
Wright Early (P. I. 43180)
Wright Purple (P. I. 43181)

Prunus americana:
Admiral Schley
Advance
Desoto
Golden Queen
Hawkeye
Klondike
Muncy
New Ulm
Quaker
Skuyu
Stoddard
Weaver
Wolf
Wood
Wyant

Prunus americana var. *mollis* Torr. and Gray:
Gloria
Terry

Prunus nigra:
Aitken
Cheney
Eureka

Plumcots (so-called):
Francis I
Poe Royal Cot Plum
Rutland
Sharpe
Smith
Sparks
Stanford
Triumph
Velvet

Prunus insititia:
Big Mackey
California Wild

Prunus insititia—Con.
Crittenden
Damson Free
Damson Majestic
French damson
Frogmore
King damson
Merryweathers
St. Julien
Shropshire
White damson

Prunus munsoniana:
Clifford
Downing
Early June
Freestone Goose
Jewell
Late Goose
Monthalia
Newman
Oxheart
Poole Pride
Pottawattomie
Wildgoose Improved
Wooten

Native plum:
Zekanta

Prunus hortulana:
Forest Garden
Golden Beauty
Minco
Robinson
Surprise
Wayland

Prunus hortulana var. *mineri* Bailey:
Miner

Prunus bokhariensis:
P. I. 40224

Species unknown:
May Queen
Progressive
Superior

Prunus cerasifera:
De Caradenc
Early Cherry
Extra Early Cherry
Myrobalan
Paragon

Prunus angustifolia var. *varians* Wight and Hedr.:
Eagle
McCartney

Prunus orthosepala Koehne:
Prunus orthosepala

Prunus subcordata Benth.:
Sierra

Prunus simonii:
Simon

HYBRIDS OR SUPPOSED HYBRIDS

Supposed parentage[1]	Variety	Supposed parentage	Variety
S × Si	Alhambra	W × A	Kiowa
Mu × S	America	Si × S × C × Mu	La Crescent
S × ?	Apple	S × A	Loring Prize
C × S	Banana	S × ?	Los Gatos
S × Si	Bartlett	Si × S	Mammoth
S × ?	Beauty Junior	C × ?	Marianna
S × ?	Bilona	S × A	May Beauty
S × A × ?	Biola	S × Si	Maynard
I × S	Black Beauty	S × C	Methley
S × Mu?	Bruce	Mu × ?	Milton
S × A	Bursoto	(Si × S × C × Mu) × Na	Minnesota 109
S × Si × ?	Cazique	I × D	Miracle
Si × ?	Chalco	S × A	Monitor
B × A	Cheresoto	S × A	Mound
A × S	Choice	S × Ch	Mrs. Bruce
S × Si	Climax	S × (Mu × S)?	Munson
S × ?	Combination	? × Mu	Nona
I × D	Conquest	S × A	Omaha
A × Ma	Crimson Beauty	S × (Mu × S)	Opata
S × A × Si	Discovery	A × S	Patten's XX
S × Ch	Donley	(S × Si) × ?	Phoebe
(Mu × S) × S	Duarte	(S × Si) × ?	Prize
S × Si × ?	El Dorado	H × A	Reagen
S × A	Eliott	S × Ch	Red Ball
?	Elsie	S × A	Red Wing
S × A	Emerald	H Mi × *P. cerasus*	Roadside
S? × D	Endicott	?	Russian hybrid
B × Na	Epoch	S × ?	Sacramento
B × S	Etopa	B × A	Sansoto
S × Mu	Excelsior	B × S	Sapa
B × S	Ezapatan	Si × S × C × Mu	Shiro
S × ?	First	S × An V	Six Weeks
S × A	Flichinger	S × ?	Solano
S × ?	Formosa	Sp × D	P. I. 32671
S × ?	Funk	Sp × D	P. I. 32673
S × A × ?	Gaviota	S × A	Stella
(Mu × S) × ?	Gee Whiz Plumcot	S × Ch	Sweetheart
A × Si × S	Gigantic	S × (S × Si)	Tanwick
Ma × Si × A × N	Glow	S × Mu	Terrell
S × Mu	Golden	A × ?	Theo. Williams
S × Na	Gonzales	S × ?	Thunder Cloud
H Mi × A	Hammer	A × Si	Toka
A × Si	Hanska	Si × A	Tokata
S × ?	Happiness	S × A	Tonka
S × hybrid	Howe	Si × S × C × Mu	Underwood
S × hybrid	Howe	S × ?	Upright
S × A	Hoyt	S × C	Vesuvius
S × Si × ?	Inca	B × S	Wachampa
A × S	Inkpa	S × A	Waneta
S × Ch	Jewell Carpenter	S × H	Waugh
Mu × S	Juicy	S × Si	Wickson
S × ?	June Twenty-fourth	D × S	Wilma
A × Si	Kaga	S × A	Winona
A × N	Kahinta	S × ?	Zulu

MISCELLANEOUS SPECIES, NO NAMED VARIETIES

Prunus alleghaniensis, *P. besseyi*, *P. davidiana*, *P. fremonti*, *P. mexicana*, *P. mira*

[1] Key to species of parents:
A = *Prunus americana*
An V = *P. angustifolia* var. *varians*
B = *P. besseyi*
C = *P. cerasifera*
Ch = Chickasaw plum
D = *P. domestica*
H = *P. hortulana*
H Mi = *P. hortulana* var. *mineri*
I = *P. insititia*
Ma = *P. maritima*
Mu = *P. munsoniana*
N = *P. nigra*
Na = Native plum
S = *P. salicina*
Si = *P. simonii*
Sp = *P. spinosa*
W = *P. watsoni*
? = Species unknown

CHERRIES

The cherry is another very important stone fruit, although it is not grown so extensively in the United States as the peach and the plum. The varieties in which we are interested for their value as edible fruit belong to two groups, the sweet and the sour. Varieties of the former

Figure 15.—Eight-year-old trees of Napoleon sweet cherry (*Prunus avium*).

group are used principally for fresh-fruit dessert, while those of the latter make up the great bulk of the frozen and canned cherries of commerce for use in bakeries, restaurants, and homes for pies, preserves, and sauce. In fact, so important is their use for pies that this group of sour varieties is frequently referred to as pie cherries.

Unfortunately, our present-day cherry varieties are not so widely adapted over this country as we should like to have them. While the sweet cherry trees are as hardy in wood as the peach, they do not recover so well from winter injury. They blossom early in the spring, and the flowers are very susceptible to cold and frost injury. The sour cherry tree is as hardy as some apple varieties, but its blossoms are also quite tender to cold, and crops are frequently lost by spring frosts. In more southern latitudes in this country the trees do not thrive in the hot, dry summers, and in the more humid regions the fruits are very susceptible to brown rot. Chiefly because of special climatic requirements, the principal commercial production of sour cherries is limited to districts along the Great Lakes in the East, and of the sweet cherry varieties to the Pacific and Intermountain States of the West.

Classification of Cherries

All varieties of cultivated cherry belong to two species (*3, 18*). The sweet cherries, *Prunus avium* L., (fig. 15) are tall trees with few or no suckers from the roots and with leaves downy on the under side. The sour cherries, *Prunus cerasus* L., (figs. 16 and 17) are small trees with many suckers from the roots and with fruit sour to bitter in taste.

Figure 16.—Six-year-old trees of the Montmorency variety of sour cherry (*Prunus cerasus*).

Wild forms of the sweet cherry found growing in this country and in Europe are also called mazzard, bird, and wild sweet cherry. Some of these have escaped from cultivation.

The native habitat of the sweet cherry species is in southern and central Europe and Asia Minor. This species has been divided by botanists into different groups, but because of hybridization among the varieties it is rather difficult in many cases to classify them. Sweet cherries with soft, tender flesh form one group, known by pomologists under the French group name guigne or the English gean. These are also known as the heart cherries. These sweet, soft-fruited cherries may again be divided into dark-colored varieties with reddish juice, and light-colored varieties with colorless juice. Among the light-colored gean varieties are Coe, Ida, Elton, and Wood. Dark-colored ones are represented by Black Tartarian (fig. 18) and Early Purple. The second group is distinguished by the firm, crisp flesh of the fruits and is referred to as the bigarreaus. Windsor, Republican, Bing, and Lambert are representative varieties of the black type, while light types are Yellow Spanish and Napoleon (fig. 15).

The native habitat of *Prunus cerasus* seems to be close to that of *P. avium* in the region about the Caspian Sea to western Anatolia. De Candolle concludes that *P. avium* extended westward more rapidly and was the first to become naturalized. Like the sweet cherry, the sour cherry is also divided into groups based on the color of the juice. Cherries with colorless juice are the amarelles, consisting of pale-red to red fruits more or less flattened at the ends (fig. 19). Common

Figure 17.—Mature trees of Montmorency cherry in bloom. This is the important sour cherry of commerce grown in the United States.

representatives of this group are Early Richmond and Montmorency (figs. 16 and 17). The second group called the morellos, contains varieties with very dark round to oval fruits and flesh with reddish juice. Typical varieties of this group are English Morello, Ostheim, and Olivet. A third type in the species is the marasca cherry, from which is made maraschino, a liqueur used in Europe and the United States in the manufacture of maraschino cherries. The marasca cherry is a native of the Province of Dalmatia, Yugoslavia, where the trees grow wild. The fruits of the marasca varieties are much smaller and darker and somewhat more acid than the common sour cherry. In the United States at the present time some varieties of sweet cherry such as Napoleon, and some sour varieties, are being used for making maraschino cherries.

The duke cherries (fig. 20) are intermediate in type and have sometimes been referred to *Prunus avium*, but more recently have been considered to be hybrids between *P. avium* and *P. cerasus*. In France they are called royals. May Duke, perhaps one of the oldest varieties grown in the United States, Reine Hortense, and Late Duke are important varieties of this group. In the duke cherries many characteristics of fruit, skin, flesh, juice color, and flavor, as well as of tree growth, are intermediate between the sweets and sours.

Three other species of cherry that have been used by breeders are the Nanking or bush cherry, *Prunus tomentosa* Thunb., an inhabitant of central Asia; the sand cherry, *P. pumila* L., of the shores and

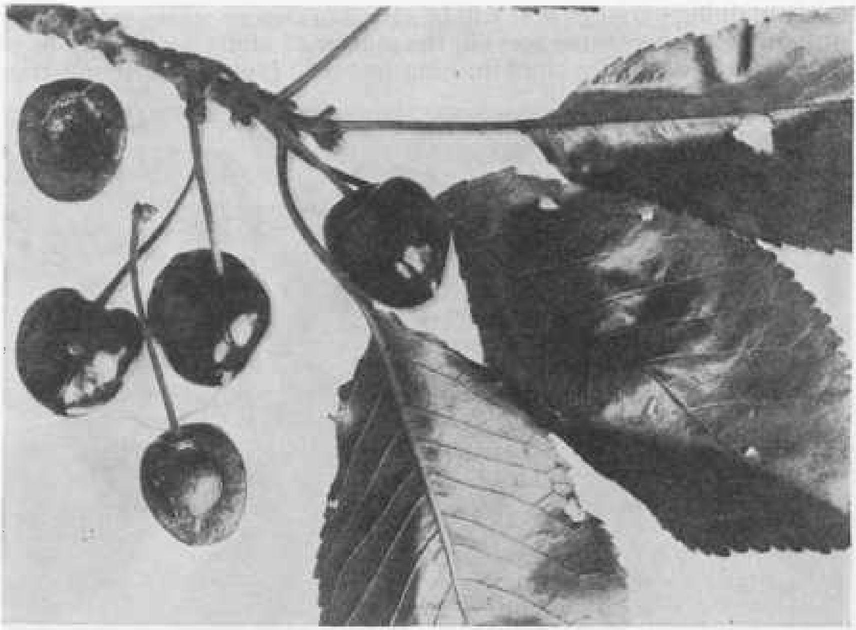

Figure 18.—Sweet cherries are more or less heart-shaped and are sometimes referred to as heart cherries. Black Tartarian, shown above, is a variety of the gean type with dark flesh and reddish juice. The bigarreau type is similar in appearance but has firm flesh.

beaches of the eastern United States; and the western sand cherry or Bessey cherry, *P. besseyi* Bailey, of the western United States.

In addition to the wild sweet or mazzard cherry, two other species are important from the standpoint of stocks on which to bud or graft varieties for propagation. These are the small wild, inedible sour cherry of southern Europe, *Prunus mahaleb* L., known as the mahaleb cherry, and the small wild red or pin cherry of the Northern States and Canada, *P. pensylvanica* L. f.

Attempts have also been made to locate pleasant-flavored strains of the chokecherry, *Prunus virginiana* L. Some strains are quite inedible until fully ripe.

Objectives in Cherry Breeding

One of the main objectives in cherry breeding is the production of high-quality sweet varieties that will prove more hardy in tree and blossom characters than many of those now available for planting. The production of such a delicious fruit as the sweet cherry is now limited to a very few regions of this country. Even in those regions where it can be grown there is need for firm-fleshed varieties that do not crack and that will ripen over a long season. At the present time we have no firm-fleshed early-ripening varieties of the bigarreau type. The unsatisfactory viability and germination of seed of early-ripening varieties impede progress in this direction at the present time.

In obtaining varieties that will be suited to regions where moderately low winter temperatures prevail, the matter of understocks may be of first importance. The chief limiting factor in growing hardy cherries

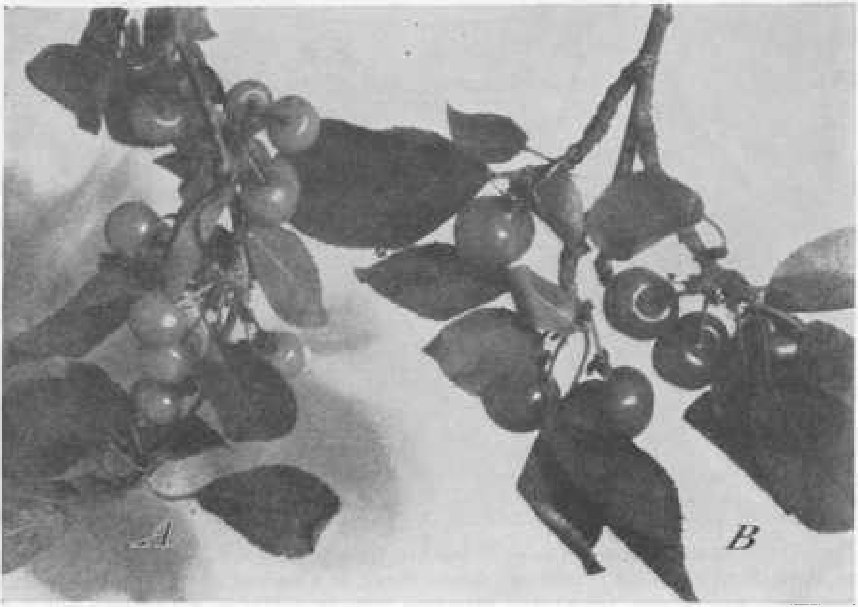

Figure 19.—Sour cherries of the amarelle group, including pale red to red types with colorless juice: *A*, Early Richmond; *B*, Saint Medard.

in the northern Great Plains area, as well as in certain other parts of the United States, is the relative tenderness of some mahaleb and mazzard stocks used in propagation. Selection of better understocks that will prove more cold-resistant and more widely adapted than those in present use is worthy of further investigation. Selections of native cherries that appear to be better adapted to various soil and climatic conditions, such as hardier strains of our native mazzard and mahaleb stocks, may prove fruitful of results (*21*). Cherries are not grown at the present time in the vast area comprising the southern part of the United States, principally because of the susceptibility of our available varieties to certain diseases. There is need for the development of disease-resistant varieties for this region.

More genetic and cytological studies are needed, particularly of hybrids between the sweet and sour varieties, as a basis for more intelligent choice of desirable parents. Some of the duke varieties are very excellent cherries but they are not highly productive. Methods of inducing polyploidy in order to obtain greater fertility in cherries has received little attention.

Methods of Cherry Breeding

The methods used in breeding new varieties of cherry are not different from those already discussed for the peach and the plum. Since all of the important varieties of *Prunus avium* have been shown to be self-unfruitful (*28*, *30*) emasculation is unnecessary, but with the sour and duke varieties the blossoms must be emasculated.

Figure 20.—Eight-year-old trees of the May Duke variety of the duke group of cherries

One of the important problems confronting the cherry breeder at present is to find methods for growing the seeds of early-ripening varieties.

Improvement in Varieties

Breeding of new varieties of cherries does not seem to have attracted the interest of private breeders to the extent noted with peaches and plums. Interest has always been maintained in a search for new varieties, but progress in obtaining them has been slow. The failure to develop new varieties may be due partly to the fact that the cherry is not at home over such a large area of this country as the peach and the plum. The tenderness of the sweet cherry (*Prunus avium*) varieties, with the resulting loss of trees during cold winters, has largely limited their culture to the more protected areas along the Great Lakes and to the Pacific and Intermountain States of the West. The failure to obtain new varieties, particularly the sweet sorts, may also be due to the failure of the seed to grow.

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The success obtained by two private breeders is worthy of mention. The pioneer breeding work of the brothers Henderson and Seth Lewelling in Oregon dates back to 1848 (*18*). In that year Henderson Lewelling carried an assortment of varieties of peach, apple, pear, plum, and cherry by wagon from Iowa to Oregon. These were planted in Milwaukie, Oreg., as a source of material for nursery and variety-improvement work. One of the most important varieties of cherry in this collection was the Napoleon. Apparently the tag had been lost, and the variety was renamed the Royal Ann, the name by which it is known in the Pacific Coast States today. From this stock of Royal Ann and other cherries, three important new varieties of the black bigarreau type were developed, Republican, Lambert, and Bing. Republican, possibly a cross of Napoleon and Black Tartarian, originated as a seedling in Seth Lewelling's orchard in 1860. Lambert originated as a seedling under a tree of Napoleon planted by Lewelling in 1848. From a seed of Napoleon planted in 1875 in Milwaukie, Seth Lewelling grew the promising seedling that later he called Bing. These excellent varieties developed by the Lewelling brothers laid the foundation for the present cherry industry in the Pacific Northwest as well as in California. The Bing, Lambert, Republican, and Napoleon are at the present time the leading commercial varieties of sweet cherry in this region.

At about the time that the Lewellings were working on the development of cherry varieties in Oregon, P. J. Kirkland, of Cleveland, Ohio, was engaged in similar work for the eastern United States. Varieties introduced by Kirkland that have been grown and are still being grown to some extent are the soft-fleshed sweet varieties Black Hawk, Kirkland, and Rockport.

In view of the results obtained by these men it is rather surprising that no enterprising breeder has become interested in more recent times in searching for better varieties and types of sweet cherries adapted to this country.

Cherry Breeding in the United States

The New York (State) Agricultural Experiment Station at Geneva has done the most work on cherry breeding in recent years. The first crosses were made in 1911. To date, about 1,200 seedlings have been planted for fruiting, and in addition there are a few hundred in the nursery for future planting. Sixty-two different sweet, sour, and duke varieties and a few seedlings have been used in the breeding studies. The varieties used most extensively were Abesse d'Oignies 33 times, Abundance 47, Bing 57, Burbank 9, Coe 16, Early Rivers 35, Early Purple 9, English Morello 46, Elton 41, Emperor Francis 45, Early Richmond 21, Giant 82, Gil Peck 15, Hedelfingen (*Géante d'Hedelfingen*) 27, Ida 12, Kirtland 50, Knight 10, Ludwig 27, Lambert 81, Lyons 58, May Duke 72, Montmorency 73, Napoleon 103, Ostheim 26, Olivet 14, Oswego 11, Reine Hortense 25, Royal Duke 9, Republican 32, Schrecken 30, Seneca 74, Schmidt 74, Windsor 59, Wood 24, and Yellow Spanish 54.

Unfortunately, many cherry seeds failed to germinate, and consequently from thousands of seeds comparatively few trees were obtained.

The seeds of early varieties were nearly 100 percent nonviable. The Seneca, a very early black sweet cherry, was produced at the Geneva station by crossing an early unknown sweet with the Early Purple. This variety originated in 1911 and was sent out for trial in 1924. The only other seedling that has been named was derived from a cross made in 1925 between Napoleon and Giant. This seedling was named Gil Peck upon request of the Indian tribes of New York, who were very fond of the late Gilbert W. Peck, a Cornell extension worker in pomology. The Gil Peck was introduced in 1926.

The objectives of the work in New York have been the production of firm-flesh sweet cherries that do not crack or rot and that ripen from early to late season. To secure lateness, large-fruited varieties were crossed with Abundance and with a small, very late, firm-flesh cherry called Oswego. Late-blooming mazzards have also been used in order to secure later blooming varieties that may escape late spring freezes.

In addition to fruit of good quality for commercial purposes, productive hardy trees have been given consideration in this work. Little work has been done with the sour (*Prunus cerasus*) group of cherry, because the present commercial varieties, Montmorency and Early Richmond, have been found fairly satisfactory for New York. The production of desirable duke cherries has also been given consideration, inasmuch as a productive high-quality duke would doubtless meet with favor among cherry producers and consumers.

In South Dakota, N. E. Hansen has been actively engaged since 1900 in breeding cherries suited to the west north central States. He has made many crosses, using the western sand cherry, *Prunus besseyi*, and other species of *Prunus*. The sweet cherries, *P. avium*, which are raised in the Eastern States and so extensively on the Pacific coast, are not hardy in the northern prairie States. The sour cherries, *P. cerasus*, are much hardier than the sweets, but they are not generally planted in this region. The Early Richmond and some other sour varieties are grown to a limited extent in the southern part of the State. Attempts to hybridize sweet and sour varieties with the native cherries have not been successful.

The following have been developed and introduced:

Select South Dakota sand cherries (*Prunus besseyi*): Sioux, Tomahawk, and S. Dak. No. 5.

Sand cherry × Japanese plum: Sapa, Wachampa, Etopa, Eyami, Enopa, Ezaptan (sand cherry × Burbank Sultan plum), Opata, Owanka, Okiya, Cikana (sand cherry × Gold plum), Skuya, Wohanka, Wakapa (probably sand cherry × unknown Japanese plum).

Sand cherry × native plum: Cheresoto, Sansoto (sand cherry × De Soto plum).

Sand cherry × plum: Champa (sand cherry hybrid, a seedling of Sioux open-pollinated), Oka (seedling of Champa open-pollinated, probably with Japanese plum).

Sand cherry × Purple-leaf Persian plum: Stanapa (purple-leaved, semi-dwarf), Cistena (purple-leaved, dwarf).

Sand cherry × European apricot: Yuksa (sand cherry × New Large apricot).

At the Iowa Agricultural Experiment Station cherry-breeding work is being carried on by utilizing greenhouse-grown trees in the same way as in the work at this station with plums and peaches. The varieties consist of six species of *Prunus*, namely, *avium*, *cerasus*, *besseyi, japonica* Thunb., *tomentosa*, and *capuli* Cav. Trees of the following crosses are being grown in the nursery: Sapa plum (*P. salicina* Lindl. × *P. besseyi*) × Gold cherry (*P. avium*); *P. serotina* Ehrh. × *P. capuli*, and Zumbra × *P. tomentosa*. The object of this work is to obtain varieties of cherry hardy for Iowa and suitable for the Great Plains region.

At the North Dakota Agricultural Experiment Station, work on cherry breeding is carried on with objectives similar to those in South Dakota and Iowa. The Cooper sand cherry hybrid was introduced in 1935. Because of good quality of fruit and hardiness of tree, it is considered a substitute for the sweet cherry in that State.

In past years about 400 seedlings of open-pollinated Compass cherry have been grown. Only one seedling had horticultural value. About 500 chokecherry selections have been grown, and from this work variety improvement seems possible from the use of these cherries as parents. Fifty F_1 seedlings were obtained from crosses made in 1926 of chokecherry × *P. maackii* Rupr. These seedlings are also of genetic interest and are under study. Seedlings of hardy Russian sorts and of open-pollinated Anoka are also being grown.

At the United States Northern Great Plains Field Station at Mandan, N. Dak., sour and sweet varieties of cherries have been crossed with pin cherries (*Prunus pensylvanica*), western sand cherries (*P. besseyi*), Nanking cherries (*P. tomentosa*), and chokecherries. Seeds have been produced, but in most cases they failed to grow. One tree, a cross between Wragg and pin cherry, seems to be fairly drought-resistant and hardy. It blooms profusely but does not set fruit, probably because of self-unfruitfulness.

Several hundred pin cherry seedlings have borne fruit, but none has been good enough to select.

Several thousand western sand cherry seedlings have been grown. This hardy native fruit shows a decided and varied response to cultivation; there are marked variations in habit of growth and in size and quality of the fruit. A number of promising selections have been made and propagated for further testing. This fruit has also been used in crossing with plums and Nanking cherries. Some of the latter crosses are bearing, and both fruit and bush characteristics are intermediate between the western sand cherry and the Nanking cherry. Second-generation seedlings have been grown.

Large numbers of chokecherry seedlings have been grown, and while they show considerable variation, no real "chokeless" seedling, i. e., entirely nonastringent, has been found. A few of the best have been propagated on *Prunus maackii* stock for further testing.

Thousands of seedlings of the Nanking cherry have been fruited in the testing blocks. This fruit is not entirely hardy and tends to be a shy bearer. It has been used in crossing with standard varieties of cherries, the western sand cherry, and plums. The only viable seeds obtained were from the western sand cherry crosses.

In addition to the breeding work at the various institutions, extensive variety collections are located in a number of States where breeding material may be obtained. Some of these are the New York (State) Agricultural Experiment Station, the Ohio Agricultural Experiment Station at Wooster, the Colorado State College at Fort Collins, the Utah Agricultural Experiment Station at Ogden, the California Agricultural Experiment Station at Davis, and the Oregon Agricultural Experiment Station at Corvallis.

Cherry Breeding in Canada

Cherry-breeding work at the Horticultural Experiment Station at Vineland, Ontario, Canada, was begun in 1915 and has been continued up to the present time. During the period 1915 to 1935, 2,587 seedlings were obtained and planted for study. These seedlings were from 27 variety crssoes and 27 open pollinations. Sixteen have been selected as having horticultural value. Two hundred and eighty-one seedlings were obtained from crosses made in 1931, using Bing as the seed parent and Black Tartarian, Napoleon, and Victor as pollen parents, to obtain large, nonsplitting, black varieties. From crosses made in 1935, 1,040 seedlings have been obtained from Hedelfingen as seed parent and Black Tartarian, Bing, Victor, and Windsor as pollen parents, with the same object in view.

From the early cherry-breeding work the Victor variety was introduced in 1935. This variety was a selection from seed of open-pollinated Windsor, which was collected in 1916 by F. S. Reeves. It is a large, attractive white cherry. Approximately 4,000 trees of this variety have been planted in southern Ontario.

Self-Fertility in Cherry Varieties

Gardner (*14*), in 1911, working in Oregon, failed to get a set of fruit from selfing 11 varieties of sweet cherry. In 1912 he attempted to intercross Bing, Lambert, and Napoleon. These varieties proved to be not only self-incompatible, but incompatible with each other, that is, they would not set fruit when selfed or when cross-pollinated among themselves. In orchards where Napoleon was interplanted with Republican, and away from the influence of other varieties, the Napoleon set a full crop. The same was true where Lambert and Bing were interplanted with Black Tartarian.

The results of early cherry pollination work from 1911 to 1913 in Oregon, as well as later work in that State and in California, show that all varieties of sweet cherry tested were self-incompatible. Republican, Black Tartarian, Coe, Early Purple, Elton, Knight, Major, Francis, May Duke, Rockport, Waterhouse, Willamette, Windsor, and Wood were all self-incompatible. Republican and Black Tartarian were found to be good pollinizers for all the varieties. They, of course, do not set fruit when selfed.

Crane and Lawrence, working in England, have tested 33 varieties and found all of them to be self-incompatible. Important self- and cross-incompatible varieties were Black Eagle, Early Rivers, Knight (Knight's Early Black), and Bedford Prolific, while among cross-compatible varieties were Black Tartarian, Schmidt, Wood, and Windsor.

For all practical purposes, therefore, we must consider all true sweet-cherry varieties of *Prunus avium* to be self-unfruitful, that is, no fruit will set from blossoms pollinated with their own pollen, since fertilization will not take place. The genetic explanation of self-incompatibility of style and pollen and its relation to failure of fruit to set has already been discussed in the section on plums.

Types of Sterility

Nearly all of the varieties of sweet cherries fail to set fruit when the flowers are pollinated with their own pollen. They are therefore said to be self-sterile. However, the pollen grains and egg cells of these varieties are functional, for the pollen will grow when placed on the stigma of another variety, and in like manner the egg cell will develop if fertilized with pollen of another variety. With most of the stone fruits fertilization is required before the fruit will develop, and a variety that does not set fruit because of the failure of its own pollen to effect fertilization of the flowers is said to be self-unfruitful.

Strictly speaking, sterility may be due to three causes (*23*): (1) Flowers may be sterile because of their morphological development. Failure of the anthers or pistils, or both, to develop, and failure to develop viable pollen or functional egg cells, may result in nonfruitfulness. It is recognized that such situations may be due to genetic causes. (2) Sterility may also be physiological. The pollen grains and egg cells may be normal; fertilization is effected, but the embryo does not grow because of certain nutritional disturbances. (3) Sterility may be due to incompatibility. In this case the pollen grains are normal and will develop in the style of other varieties and bring about fertilization of the ovules, but they will not function in the style of the flower of the same variety. It is this latter type of sterility that is most frequently encountered in the stone fruits. Nearly all of the sweet cherry varieties are self-unfruitful because of incompatibility. Varieties such as Napoleon, Windsor, and Black Tartarian will not set fruit when the flowers of any one of them are pollinated with its own pollen. If, however, Black Tartarian pollen is applied to Napoleon or Windsor, a large percentage of the flowers will set fruit. Likewise, if Windsor pollen is applied to Napoleon or Black Tartarian, fruit-setting will occur.

The genetic basis of incompatibility has already been discussed in the section under plums.

Genetic and Cytological Studies With Cherries [10]

In contrast to the sweet cherries, varieties of sour cherries are self-fertile, and the pollen of sour varieties will also effectively cause fruit-setting on sweets.

In duke cherries varying degrees of self-compatibility occur. Crane and Lawrence (*10*), working in England at the John Innes Horticultural Institution, have obtained the following percentage of set from selfing important duke varieties: 9 percent for Late Duke, 3 percent for Empress Eugenie, 1 percent for May Duke. Reine Hortense set no fruit. The results obtained from cross-pollinations between sweet,

[10] This section is written primarily for students or others professionally interested in genetics or breeding.

sour, and duke cherries have varied considerably. According to Crane and Lawrence, sweet varieties pollinated by sour varieties generally produce and mature fruits freely, but from reciprocal pollinations fruits are less freely formed. In a similar way fruit production is less when the dukes are pollinated by sweet varieties than when reciprocal pollinations are made.

We have little knowledge about the origin of our present cherry varieties. Three varieties produced by Thomas Andrew Knight, resulting from a cross of a sweet (bigarreau) × May Duke, were Waterloo, Knight (Knight's Early Black), and Black Eagle, and the latter two would pass for sweet cherries. In pollination studies to determine the incompatibility of varieties, it has been observed, both in this country and in England, that individuals of the same variety appear to differ in their pollination requirements, and it is possible that distinct strains of such varieties or types as Black Tartarian or Napoleon have been propagated. Because of the fact that all varieties of *Prunus avium* are self-unfruitful it has been impossible to raise selfed progeny to study the inheritance of characters and determine genetic relationships. In studies made at the John Innes Horticultural Institution in England, Crane observed that in selfed families raised from varieties of *P. cerasus*, seedlings with *P. avium* characters frequently appeared, and in families raised from crosses between varieties of *P. avium*, occasional seedlings occurred which showed marked *P. cerasus* characters. Furthermore, seedlings in families raised from *P. avium* × *cerasus* resembled the dukes in many characters but not in all.

Cytological investigations of the cherries show the somatic chromosome number ($2n$) in *P. avium* to be 16, and it is apparently diploid. In *P. cerasus* and the dukes the number is 32. Darlington (*11*), who has studied the chromosome behavior in a number of cultivated varieties of cherry, considers that *P. cerasus* is a true tetraploid, not derived simply from *P. avium*, but one possessing additional elements probably derived from *P. fruticosa* Pall., another tetraploid. All of the sweet cherries examined by Darlington had extra chromosomes beyond the diploid number. Irregularities occur in chromosome pairing, but it does not appear that there is any correlation between the actual chromosome number and the incompatibilities observed in sweet cherry varieties. Selfed seedlings of sour and duke varieties showed a chromosome number of 32. In crosses between the sour and dukes an examination of the progeny shows that the chromosome number is also 32. However, in crosses between dukes and sweets, and sours and sweets, the progeny showed the intermediate number 24 in some cases, as we might expect, and in others 32. The cultivated duke varieties appear to be tetraploids that have arisen from hybridization between the diploid sweet cherries and the tetraploid sours. In experimental studies, however, crosses between some tetraploid sours and diploid sweets have yielded seedlings with 24 chromosomes that presumably were triploids and proved to be highly sterile.

B. R. Nebel, at the New York Agricultural Experiment Station, has been studying the cytology of interspecific hybrids. From crosses between sour and sweet cherries, 22 triploid first-generation trees have been obtained, and these are fruiting on the station grounds. In attempting to backcross from these hybrids only 1 fruit was obtained in 700 pollinations. Open-pollinated seed was then used, and this gave nearly 50 second-generation seedlings. Upon cytological examination of this second-generation material there appeared to be a gradation downward in chromosome numbers through loss of some of the supernumerary chromosomes of the sour species. It is possible that the second-generation seedlings will be more fertile than the first-generation, and that backcrosses with firm-fleshed sweet cherries will give diploid dukes that are interfertile with sweet cherries. As already mentioned, if autopolyploidy could be induced, the first-generation triploids could be made fertile directly and much time could be saved.

Crane and Lawrence report from their studies of the inheritance of flesh color in sweet cherries that white is recessive to black. In crosses between white varieties only white was obtained. Bigarreau du Schrechen is considered homozygous for black, since in all crosses where this variety was used as a parent all of the progeny produce black fruits. Other black varieties, such as Early Rivers, Bedford Prolific, Black Tartarian types A and B, Late Black, and Schmidt, are heterozygous for flesh color. It appears, however, that when the different shades of fruit color are considered, ranging from dark to white, through various pinks and reds, a number of genes may be involved in color inheritance.

Selfed sour cherry (morello) varieties with roundish oblate fruit gave seedlings that yielded occasional long fruits. Kentish Red, a variety with roundish oblate fruits, gave a progeny that yielded fruits of variable size and shape.

Appendix (Cherry)

Table 8.—*Locations of cherry-breeding work and names of workers in the United States and Canada*

State or country, institution and location	Early workers	Workers actively engaged at present
California:		
Agricultural Experiment Station, Davis.	A. A. Hendrickson, W. P. Tufts, G. L. Philp.	W. P. Tufts, G. L. Philp, E. C. Hughes.
Iowa:		
Agricultural Experiment Station, Ames.	S. A. Beach	T. J. Maney.
New York:		
Agricultural Experiment Station, Geneva.	S. A. Beach	U. P. Hedrick, R. Wellington, G. H. Howe, B. R. Nebel.
North Dakota:		
United States Northern Great Plains Field Station, Mandan.	Max Pfaender	W. P. Baird.
Agricultural Experiment Station, Fargo.		A. F. Yeager.
South Dakota:		
Agricultural Experiment Station, Brookings.	N. E. Hansen	N. E. Hansen.
Utah:		
Agricultural Experiment Station, Logan.		F. M. Coe
Canada:		
Horticultural Experiment Station, Vineland, Ontario.		F. E. Palmer, G. H. Dickson.

Cherry Material at the California Agricultural Experiment Station, Davis, Calif.[11]

Prunus tomentosa:
- Var. Bush Cherry (P. I. 36086)

P. pseudocerasus:
- Var. Tangsi (P. I. 18587). (Season very early.)

P. avium:
- Abundance
- Allen
- Bassford
- Bauman May
- Bedford Prolific
- Belle de Drureo
- Belle d'Orleans
- Best
- Biggareau Blanc d'Espagne
- Bigarreau d'Italie
- Bing
- Black Oregon
- Black Republican
- Black Sweet
- Black Tartarian
- Bohemian
- Burbank
- Burr's Seedling
- Bush Tartarian
- California Advance
- Centennial
- Chapman
- Cleveland
- Coop's Special
- Deacon
- Dikeman
- Dr. Flynn
- Double White
- Downer
- Dyehouse
- Early Purple Guigne
- Early Rivers

P. avium—Continued.
- Elton
- Emperor Francis
- Garrafal
- Garrafal le Grand (P. I. 33223)
- Giant
- Gold
- Hedelfingen
- Hinton
- Hoskins
- Improved Black Tartarian
- Jaboulay
- Knight
- Koontz Mammoth
- La Cima
- Lamaurie
- Lambert
- Late Bing
- Lewelling
- Long Stem Royal Ann
- Long Stemmed Waterhouse
- Major Francis
- Mezel
- Napoleon
- Ord
- Ostheimer Weichsel
- Oxheart
- Paul
- Pontiac
- Porter's Tartarian
- Ramon Oliva
- Roe
- Royal Stewart
- Saylor
- Schmidt
- Seneca
- Sharp

P. avium—Continued.
- Shelton
- Negro de la Rivera (P. I. 73456)
- Risada de Kenter (P. I. 73457)
- Thompson
- Transcendens Black Heart
- Vaughn
- Waterloo Heart
- White Carron
- Willamette
- Windsor
- Wood

P. cerasus:
- Baldwin
- Dyehouse
- Early Richmond
- English Morello
- Homer
- Large Montmorency
- Montmorency
- Nelson
- Terry
- Vladimir
- Wragg

Dukes:
- Empress Eugenie
- Late Duke
- May Duke
- Minchin
- Noble
- Olivet
- Reine Hortense
- Royal Duke

Hybrids:
- New Century. Parentage, *P. cerasus* × (*P. avium* × *cerasus*).

Cherry Varieties at the New York Agricultural Experiment Station, Geneva, N. Y.

- Abbesse d'Oignies
- Belle di Barbanti (U. S. D. A.)
- Bianco Rosatio di Piemonte (U. S. D. A.)
- Bicentenaria (U. S. D. A.)
- Bigarreau de Schrecken
- Emperor Francis
- Garrafal le Grand
- Geante d'Hedelfingen (Germany). (Synonym of Hedelfingen.)
- Giant
- Gil Peck
- Grosse Lange Lothkirsche (Germany). (Synonym of English Morello.)
- Ludwig Bigarreau
- Marasca di Verona (U. S. D. A.)
- Marasca Moscata (U. S. D. A.)
- Nero Grossa di Pimento (U. S. D. A.)
- Noir de Guben
- Seneca

[11] This list contains, besides well-known varieties, local selections and other sorts the names of which cannot well be made at this time to conform to the code of nomenclature.

APRICOTS

The apricot is prized by all who like the stone fruits, and when eaten fresh it is considered by many to be the most delectable of this group. Unfortunately, however, very few apricots are grown for fresh fruit in the States east of the Rocky Mountains, and most people know the flavor of this fruit only from the canned or dried product. Its production is restricted to a relatively small area in this country where climatic conditions are favorable. Most varieties can withstand winter cold as well as peaches, but the blossom buds develop rapidly under favorable growing temperatures in late winter after the rest period is over, and the crops are frequently lost from late freezes and spring frosts.

The commercial production of the apricot (fig. 21) is confined largely to the Pacific Coast and Intermountain States (*5, 20*). California leads with a potential average production considerably in excess of 200,000 tons. Of the average crop of 266,000 tons harvested during the years 1931–33, approximately 76 percent was dried, slightly over 14 percent canned, and about 10 percent was shipped or consumed locally as fresh fruit. Because of the great perishability of this fruit and the need for quick handling, fresh apricots are on the market in the Eastern States for only a short time and their distribution is limited to large centers of population.

Botany and History of the Apricot

All of the important commercial varieties of apricot grown in this country today belong to the species *Prunus armeniaca* L. The name of the species, like that of the peach, is a geographical misnomer. The apricot was formerly considered a native of the Caucasus and Armenia, but later studies suggest that China is its native home. It is said that Alexander the Great brought the apricot from Armenia to Greece, whence it was taken to Italy. The Romans cultivated this fruit, and it is described in the writings of Pliny and Dioscorides. It was later carried to France, and there is mention of its being in England in Turner's Herbal, published in 1562. The fruit is now cultivated in all of central and southeastern Asia, and in parts of southern Europe and northern Africa. There seems to be no mention of it in the United States until 1720, when it was said to be growing abundantly in Virginia. It was doubtless among the fruits brought into southern California early in the eighteenth century by the Mission Fathers. Its culture spread to the valleys farther north, where climatic conditions were more congenial. Wickson (*33*) reports that Vancouver found a fine orchard of fruits, including apricot, at Santa Clara in 1792. In 1935, 17 varieties were described as growing in England. Downing (*12, pp. 236–242*) names 26 varieties, and the American Pomological Society (*1*) lists 11 varieties as growing in the United States in 1879.

In tree, fruit, and flower characters the apricot seems to be somewhat intermediate between the plum and the peach. The trees are large and spreading, and in this respect are more like the peach and some of the Japanese plums. The leaves are broad, heart-shaped, dark green in color, and held erect on the twigs. The flowers are white, resembling those of the plum in color, but are borne not in clusters but singly or doubly at a node on very short stems. Like the peach, the apricot is self-fruitful and will set fruit when its blossoms are selfed. The pit is smooth, somewhat like that of the plum, but broader, somewhat flatter, and more winged. The fruit is nearly smooth, round to oblong, in some varieties somewhat flattened, and in general rather more like the peach in shape. The flesh is typically

Figure 21.—**Peach and apricot growing constitutes an important industry in California. The apricot trees, in the immediate foreground, and the peach trees in the rear are a part of a large orchard with rows 3 miles long.**

an attractive yellow to yellowish orange. The kernels of some varieties are sweet.

The peach, plum, and apricot may be readily intergrafted. The apricot does well on peach stock, but the peach on apricot stock is not entirely satisfactory.

In addition to the common apricot (*Prunus armeniaca*), which comprises all of the commercial varieties grown in this country, several other species are of interest to the breeder. The black apricot (*P. dasycarpa* Ehrh.) has fruits of small size, dark purple or black in color, and for the most part of inferior quality. The trees more closely resemble the plum and possess considerable hardiness in wood and bud.

The Japanese apricot (*P. mume* Sieb. and Zucc.) is noted principally for the ornamental character of the trees. The flowers and fruits also are very attractive.

Types native in other countries have been described as species but are classed by some authorities as subspecies. The Russian apricot (*P. sibirica* L.), is possibly a strain of the common apricot (*P. armeni-*

aca). Trees of the Russian apricot differ from the common apricot in bearing smaller fruit of poorer quality. They are considered very much hardier in their native home, but certain strains brought into this country have not shown superior hardiness under test. The trees have a characteristic upright growth habit, are thickly branched, and possess more thornlike spurs. The small fruits set in clusters.

Another probable subspecies, the Manchurian apricot (*P. mandschurica* Koehne), is a common wild tree in central Chosen. Its fruit is similar to that of the common apricot, but the leaves differ, and its bark is thick and corky. This subspecies may be a selected strain of the common apricot.

The apricot is widely distributed throughout Asia, and a large number of seedlings have been observed growing wild in various localities. In China some travelers report the apricot only as a cultivated tree, but others have found it growing wild in the northern Provinces.

Breeding Material

The apricot is less rich than some of the other stone fruits in species and horticultural varieties suitable for breeding material. The raw material consists of many old varieties introduced from England and France. Among those recognized as of English origin are Blenheim, Early Moorpark, Moorpark, and Hemskirke. These are all varieties, of high quality, with the Blenheim maintaining first importance as a commercial variety. Varieties of French origin are Peach, Oullins Early, Montgamet, Luizet, and Royal. Royal is the most important commercial variety of this group. Like the English varieties, all the French varieties have certain commercial limitations. There is an excellent opportunity for the apricot breeder to combine their desirable characters by cross breeding. Work of this kind is already under way at State and Federal agricultural experiment stations, as will be pointed out later.

A large number of varieties have been introduced from the Union of Soviet Socialist Republics, many of these by J. L. Budd, of Iowa. As a class they are more hardy in bud, later in blossoming, with fruit of smaller size and poorer quality, but they are very productive. Some of the more important varieties of this group are Alexander, Budd, Gibb, Shense (Acme), Superb, and Toyahvale. Little work has been done in combining the qualities of these hardy sorts, which some botanists consider a separate species (*Prunus sibirica*), with the commonly grown varieties from western Europe.

In the last half century a number of promising seedlings and strains of American origin have been selected, but only the Tilton ranks with the older European sorts as an important commercial variety. As might be expected, most of the American varieties originated in Pacific Coast States. Among the more important are Newcastle, Alameda Hemskirke, Routier Peach, Derby Royal, and Sparks Mammoth, from California. Other varieties of more recent origin are Wenatchee Moorpark, which has been reported to be similar to if not identical with Moorpark, Riland, Gilbert, and Sofia, originating in the State of Washington. Among other older American varieties are Early Golden and Superb.

The apricot has been crossed with varieties of plum, particularly the Japanese plum. Luther Burbank produced a number of seedlings by crossing the apricot with this plum. Some of the more promising of these have been introduced under the group name plumcot. Among the more important are Apex, Corona, Rutland, Silver, and Triumph.

The crosses of apricot with plum have apparently been more successful than those with peach. No horticulturally satisfactory peach-apricot varieties have been reported.

Objectives in Apricot Breeding

If apricot culture is to be extended beyond the present restricted areas where climatic conditions are favorable, varieties must be developed that are later in flowering in spring. From material that has been brought into this country, differences in bud hardiness and in blooming have been observed. There is need for the introduction of varieties from countries where apricots are growing and surviving temperatures as low as those obtaining during the winter months in this country. Many of these will doubtless prove worthless from the standpoint of edible fruit quality, but will serve as breeding material for the development of better varieties. In California considerable loss results from the dropping of blossom buds of certain varieties. Varieties that have a short rest period, are needed for those sections of the country where the winter temperatures are not low. Better canning, drying, and shipping varieties are also in demand. Evidence at hand would indicate that the commercial quality of varieties can be improved by breeding.

There is little information about the development of varieties by private breeders. A number of chance seedlings have been discovered by individuals, but it does not appear that any conscious attempt to select or breed new varieties has been carried on to the extent that it has with the other stone fruits. It is likely that many who were interested in better varieties were discouraged in their attempts because the parent material available for crossing was in itself not sufficiently hardy.

In the selection of material for breeding, difficulty may be encountered in establishing the trueness to name of varieties, since the same variety may be grown in two or more localities under different names. Some of the varieties representing desirable types are Moorpark, Royal, Blenheim, Tilton, Montgamet, and some selections of Russian and Japanese origin. For breeding studies in the eastern United States, where hardiness is an important factor, varieties should be used that have been tested and have demonstrated superior hardiness, such as strains of Russian varieties introduced by Budd, and more recent importations made by Hansen, of South Dakota, and the Division of Plant Exploration and Introduction, Bureau of Plant Industry, United States Department of Agriculture.

Apricot Breeding at State and Federal Stations

Apricot breeding was started at the New York (State) Agricultural Experiment Station in 1922. Eighteen varieties, one seedling, and two P. I. numbered seedlings have been used. Eighty-four seedlings derived from definite crosses, 1,424 from open cross-pollination, and 9 from self-pollination have been set in the orchard for fruiting. Varieties used most extensively have been Alexis 6 times, Doty (a local seedling) 15, Downing (late blooming) 5, Montgamet 6, Oullins Early 13, St. Ambrose 5, and Toyahvale 5. A seedling grown from a seed imported by the Department of Agriculture as P. I. 34265 has been considered worthy of a name. This variety was temporarily called "Frascati", as the seed was thought to have been imported from the vicinity of Frascati, Italy, but more recently it has been given the name Geneva.

At the North Dakota station apricot breeding work was started in 1924 in an attempt to develop varieties of sufficient hardiness to stand the winters of the northern Great Plains area. Over 2,000 seedlings are being grown and studied for their hardiness and quality of fruit.

At the South Dakota station, N. E. Hansen has been propagating trees from seeds collected by him in northern Manchuria in 1924. The fruits were taken from trees growing in localities reported to have minimum temperatures of $-47°$ F. Twenty-three selections, called the Manchu group, have been propagated for test. Additional collections made in 1934 in eastern Siberia for propagation at Brookings are expected to give seedlings with greater hardiness than the Manchu.

Breeding work at the California station at Davis, Calif., was started in 1930. The objective is the development of varieties of high quality suitable for shipping as fresh fruits, canning, and drying, but lacking some of the faults of the old varieties now grown commercially. Varieties used as pollen and seed parents have been Tilton, Royal, Hemskirke, Blenheim, St. Ambroise, Peach, Newcastle, Moorpark, Oullins Early, and in addition strains of Moorpark and Hemskirke. In the seasons of 1933 and 1934, one seedling each was obtained from the following interspecies crosses: Royal × *Prunus pseudocerasus*, *P. mume* × Royal, Pringle Late × Rutland plumcot, Diamond Jubilee nectarine × Royal, and Lovell peach × Royal. From the crosses made during 1930–35 there are at the present time over 2,000 seedlings growing in the orchard.

This material should provide a sufficiently large progeny for genetic studies of the varieties used as parents and serve as a source of superior seedlings that may be worthy of naming. A list of the crosses and the number of seedlings in each cross, as well as a list of varieties now being grown, is given in the appendix to this section.

At Palo Alto, Calif., apricot breeding by the United States Department of Agriculture in cooperation with Leland Stanford Junior University has been in progress since 1922. A search for varieties of high quality that would prove more satisfactory for the established apricot districts has been the main objective of this work. About 60 promising hybrids have been selected for further studying and testing. The more common varieties, such as Blenheim, Tilton, Moorpark, Royal, Newcastle, and Hemskirke, have been used as seed and pollen parents, and in addition the less common varieties Bergetti, Montgamet, McKinley, Luizet, Bremner, and Sparks. Hybrids of these varieties have been recrossed, and other combinations have been made by using promising parents introduced from southern Europe, Africa, and Asia in an effort to obtain certain desirable characteristics in the progeny. In this material from abroad are included Giallo di Tortona, Tunis seedlings, Japanese seedling 26018, Sardinian, P. I. 28954, and P. I. 34272.

A list of the hybrids selected with the parentage and the years the crosses were made is given in the appendix.

Apricot Breeding in Other Countries

A program of apricot breeding has been under way for some time under the supervision of the Department of Agriculture at the Yanco Experiment Farm, Sydney, New South Wales. The work has for its object the production of superior canning varieties, particularly later varieties than Trevatt, to extend the season and thus close the gap of ripening between the latest canning apricots and the earliest canning peaches. Importations of seed have been made from Palestine, Iraq, Syria, and Morocco, and from this material seedlings are now being grown. The varieties used in the crosses and for open pollination are Alsace, Bouche Peche, Mansfield, Moorpark, Lossie Blenheim, Tilton, Campbellfield, Bathurst, Trevatt, Newcastle, and Rose de Vaucluse. From results obtained to date, Moorpark seems to be the best parent variety for giving a useful range of seedlings, while Trevatt cross-bred seedlings have better general quality. A Moorpark × Bouche Peche seedling is being propagated for orchard trial.

In Morocco, work is being carried on at the new State station at Ain Taoujdat, especially designed for research in horticultural genetics. New varieties of high quality are being sought for by hybridization. Ten distinct forms of native apricot (mechmech) have been studied comparatively since 1934 for their value as stocks. Superiority has been shown by E. F. 136, 137, and 139.

Genetic and Cytological Studies With Apricots

There is little published information dealing with the genetics of hybrid progenies of apricot varieties and species.

Cytological studies have been made at the agricultural experiment stations of New York and California, and all apricot varieties examined thus far have 16 as the diploid ($2n$) number of chromosomes, which is the number found in sweet cherry, peach, and some species of plum. At the New York (State) Agricultural Experiment Station, chromosome numbers in exceptionally vigorous seedlings and also in abnormal seedlings from embryo cultures have been counted, but in a total of about 50 cases no deviation from the regular diploid type was found. Unsuccessful attempts have been made to induce polyploidy by selecting giant pollen grains under the microscope, mounting them on hairs, and applying them to the stigmas of flowers. Radiation experiments with stem meristem have also failed. This work is being continued, and other methods to induce polyploidy in apricots are being tried.

Cytological investigations are under way at the California station to determine the true hybridity of the plumcots. This is important in breeding work, to determine whether the characters in segregation will behave as true hybrids or whether they will behave separately as plums or apricots.

Appendix (Apricot)

Table 9.—*Locations of apricot-breeding work and names of workers in the United States and other countries*

State or country, and institution	Location	Workers actively engaged
California:		
Agricultural Experiment Station	Davis	W. P. Tufts, E. C. Hughes.
U. S. Department of Agriculture	do	J. R. King.
Do	Palo Alto	W. F. Wight.
New York: Agricultural Experiment Station.	Geneva	R. Wellington, Olav Einset.
North Dakota:		
Agricultural Experiment Station	Fargo	A. F. Yeager.
U. S. Department of Agriculture	Mandan	W. P. Baird.
South Dakota: Agricultural Experiment Station.	Brookings	N. E. Hansen.
Utah: Agricultural Experiment Station	Logan	F. M. Coe.
New South Wales: Department of Agriculture.	Sydney	H. Wenholz.
Morocco: Experimental Laboratory	Ain Taoujdat	Ch. Miedzyrzechi.

Table 10.—*Apricot seedlings growing at the California Agricultural Experiment Station, Davis, Calif.* [1]

Year of cross	Seedlings planted	Parents	Year of cross	Seedlings planted	Parents
	Number			*Number*	
1931	72	Tilton × Moorpark.		57	Royal × Grace.
	574	Royal × Newcastle.	1932	8	St. Ambroise × Tilton.
	104	Royal × Hemskirke.		22	St. Ambroise × Moorpark.
	226	Royal × Moorpark.		8	Peach × P. I. 38281.
	230	Royal × Tilton.		4	Peach × Tilton.
	31	Wenatchee Moorpark × Tilton.		43	Wenatchee Moorpark × Oullins Early.
	2	Wenatchee Moorpark × Royal.			
	21	Hemskirke × Tilton.		1	Derby × Alameda Hemskirke.
	5	Hemskirke × Moorpark.	1933	2	Newcastle × Peach.
	149	Hersey Moorpark × Royal.		1	Tree (22-1) × Peach.
	33	Blenheim × self.		1	Royal × *Prunus pseudocerasus*.
	7	St. Ambroise × Royal.		1	*Prunus mume* × Royal.
	93	St. Ambroise × Tilton.	1934	1	Pringle Late × Rutland plumcot.
	172	St. Ambroise × Moorpark.			
1932	13	Royal × Peach.		1	Diamond Jubilee nectarine × Royal.
	10	Royal × Wenatchee Moorpark.			
	185	Royal × Oullins Early.		1	Lovell peach × Royal.
	25	Royal × Alameda Hemskirke.			

[1] Verification of the nomenclature used in this and the following lists has not been possible in all cases. Where doubt exists as to the identity of a variety referred to by a name of uncertain validity, no attempt has been made to bring such name into conformity with the code of nomenclature, as it might later result in confusion.

Apricot-Breeding Material at the California Agricultural Experiment Station, Davis, Calif.

Prunus armeniaca:
- Alameda Hemskirke
- Alexander
- Alexis
- Bairam Ali
- Barry
- Beaugé
- Bizant Royal
- Blackmon
- Blenheim
- Blush
- Bolton
- Boulbon

Prunus armeniaca—Con.
- Brady
- Breda
- Budd
- Burtons Royal Seedling
- B. W. Marshall
- Catharine
- Chinese
- Cluster
- Colorado
- Cream
- Crisomelo
- Cutler

Prunus armeniaca—Con.
- Derby Royal
- Di Breda
- Early Cluster
- Early Golden
- Early May
- Garlach
- Giallo di Tortona
- Gibb
- Gilbert
- Great Plains
- Giffin Choice
- Grosse Pêche

Prunus armeniaca—Con.
Gross Blanca Precoce
Harris
Hemskirke
Hersey Moorpark
Janet
Jones
Kaleden
Knobel Blenheim
Lampasas
Large Early Montgamet
Lewis
Losse Blenheim
Lowe
Luizet
Mammoth White
Maxson
McKinley
Meyer Giant
Miner
Mognaga
Montgamet
Moorpark
Murgab
Nellie
Newcastle
New Large Early
Nicholas
Noble
Oullins Early

Prunus armeniaca—Con.
Particolare
Paviot
Peach
P. I. 20072
P. I. 28960
P. I. 34265
P. I. 34270
P. I. 38281
Pringle
Pringle Late
Red Beauty
Riland
Rivers
Rivers Early
Routier Peach
Royal
Rualt
Santa Fe
Sardinian
Sharpe
Shense (Casaba, Acme, Yakimene)
Sloan
Smyrna
Snowball
Sophia
Sparks Mammoth
St. Ambroise
Stella

Prunus armeniaca—Con.
Stephens
Stewart
Sugar
Superb
Tentazione
Thissell
Thompson Early
Tilton
Toyahvale
Trevatt
Upham No. 1
Upham No. 3
Wenatchee Moorpark
Wiggin
Wilson
Zuccherino di Holub

Prunus armeniaca, var. *ansu* Maxim.:
Apricot Plum

Prunus dasycarpa:
Black
Florizan
Prunus dasycarpa No. 13

Prunus mume:
Bongoume
Double Flowering
Japanese (P. I. 45523)

Prunus brigantiaca Vill.
Prunus sibirica

Apricot Hybrids Produced and Under Test at Palo Alto, Calif., in Cooperation Between the United States Department of Agriculture and Leland Stanford Junior University

Year	Parents of hybrids
1923	Bergetti × Montgamet.
1931	(Bergetti × Montgamet 30–37[1]) × (Blenheim × Tilton 27–50).
1934	(Bergetti × Montgamet 30–36) × Bremner.
1932	(Bergetti × Montgamet 30–36) × (Moorpark × Blenheim 28–52).
1923	Blenheim × McKinley.
1935	(Blenheim × McKinley 27–21) × (Blenheim × Moorpark 12–58).
1920	Blenheim × Moorpark.
1932	(Blenheim × Moorpark 12–55) × Japanese seedling 26–19.
1932	(Blenheim × Moorpark 12–59) × (Sparks × Blenheim 37–60).
1935	(Blenheim × Moorpark 12–58) × 75222 Tunis 27–70.
1935	Blenheim × (Sardinian × Royal 37–56).
1923	Blenheim × Tilton.
1934	(Blenheim × Tilton 27–50) × (Bergetti × Montgamet 30–35).
1933	(Blenheim × Tilton 28–6) × (Blenheim × Moorpark 12–59).
1934	(Blenheim × Tilton 27–50) × (Blenheim × Tilton 28–6).
1934	(Blenheim × Tilton 28–7) × (Blenheim × 28954 13–26).
1932	(Blenheim × Tilton 27–47) × Bremner.
1931	(Blenheim × Tilton) × Hemskirke.
1935	(Blenheim × Tilton 28–6) × Japanese seedling 26–18.
1932	(Blenheim × Tilton 27–50) × (Moorpark × Blenheim 28–52).
1932	(Blenheim × Tilton 28–6) × (Sparks × Blenheim 37–60).
1933	(Blenheim × Tilton 28–7) × (Blenheim × Tilton 27–50).
1934	(Blenheim × Tilton 27–50) × (34272T2 × Blenheim 12–51).
1921	Blenheim × 28954.
1934	Bremner 9–27 × (Blenheim × 28954 13–26).
1933	Cirio 13–5A × (Blenheim × Moorpark 12–59).

[1] Numbers following variety name refer to row and tree location of the parent.

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Year	Parents of hybrids
1924	"Crow apricot seedling".
1920	*Prunus dasycarpa* × Blenheim.
1927	Giallo di Tortona × Moorpark.
1932	Giallo di Fortona × (Moorpark 9–16 × Japanese).
1933	Hemskirke × (Blenheim × Tilton 27–50).
1935	Japanese seedling[2] 26–18 open 27–34C × (Blenheim × Moorpark 12–58).
1935	Japanese seedling 26–18 × (Sardinian × Royal 37–56).
1923	Luizet × Moorpark.
1931	(Luizet × Moorpark 28–39) × Blenheim.
1923	Moorpark × Blenheim.
1931	(Moorpark × Blenheim 28–52) × (Blenheim × Moorpark 12–56).
1932	(Moorpark × Blenheim 28–42) × (Blenheim × Tilton 28–6).
1935	(Moorpark × Blenheim 28–52) × (Sardinian × Royal 2–25 37–56).
1923	Moorpark × Tilton.
1931	(Moorpark × Tilton 28–13) × Hemskirke.
1933	(Moorpark × Tilton 28–12) × (Moorpark × Blenheim 28–52).
1921	Moorpark × P. I. 28954.
1932	(Moorpark 15-28 × P. I. 28954) × Bremner.
1932	Newcastle II 27–16 × Japanese seedling.
1923	Royal × Blenheim.
1933	Royal × (Blenheim × Tilton 28–6).
1935	Royal × Japanese seedling 26–18.
1923	St. Ambroise × Luizet.
1931	Sardinian × Japanese seedling.
1925	Sardinian × Royal.
1925	Sparks Mammoth × Blenheim.
1935	(Sparks Mammoth × Blenheim 37–59) × (Blenheim × Moorpark 12–58).
1932	(Sparks Mammoth × Blenheim 37–59) × Bremner.
1923	Tilton × Moorpark.
1933	(Tilton × Moorpark 30–23) × (Blenheim × Tilton 27–48).
1933	Tunis 27–7A × (Moorpark × Blenheim 28–52).
1920	P. I. 34272T2 × Blenheim.
1932	(P. I. 34272 × Blenheim 12–50) × (Sparks Mammoth × Blenheim 37–60).

Apricot Breeding Material at the New York (State) Agricultural Experiment Station, Geneva, N. Y.

Crisemelo seedling, P. I. 34269.
Geneva.
Henderson.
Ispharak Kandak (Russia).
Murgab (P. I. 32834).
Mulla-gadai (Russia).
Paviot (Germany).
Rittenhouse.
Schik-Usbekistan (Russia).
Toyahvale.
Ungarishe.

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[2] "Japanese" variety from John Rock collection at Niles, Calif. Tree was not labeled, and nothing is known of its origin.

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